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Quaternary Stratigraphy of the Sand River Area, NTS 73L

by

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
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Supervisor

John England ....

C.R. Stelck ....

J. Shetsen ....

Date ......Jan 31, 1985..........................

ABSTRACT

Eight glacial and non-glacial formations have been defined for the Quaternary sequence in the Sand River area. The thick drift cover, combined with a paucity of exposures, necessitates reliance on testhole data for the differentiation and correlation of these units. The stratigraphy of the upper 50 m is defined primarily from matrix texture and carbonate content, and 1-2 mm sand composition data derived from dry auger samples at 1 m intervals. Rotary drill samples and electric log responses are essential to define the deeper stratigraphy.

The relative abundance of four rock groups (igneous and metamorphics, quartz, carbonates and local bedrock) within the 1-2 mm sand fraction is the most useful criteria in differentiating the till. The proportion of these rocks commonly show a systematic change with distance from the source, consequently a ratio of their abundance, rather than the absolute percentages, is used to differentiate the tills within a local sequence. The standardization of electric log responses with the analytical values enable correlations of the units beyond areas where samples were collected. Textural and lithologic variations allow the division of some formations into units or members.

The formations have been informally defined with designated type sections. The Empress Formation is the oldest, and is divided into three units on the basis of lithology: unit 1, preglacial sand and gravel, unit 2, silt and clay, and unit 3, glacial sand and gravel. The Bronson Lake Formation overlies the Empress Formation. It consists of clayey till and clay deposited by the first recognized glacier in the area, the Cherry Grove Glacier. Glaciofluvial sand and gravel of the Muriel Lake Formation were deposited on top of the Bronson Lake Formation, following the retreat of the Cherry Grove Glacier, and during the advance of the Fort Kent Glacier. Till of the Bonnyville Formation overlies the Muriel Lake Formation. It was deposited by the Fort Kent Glacier, and is characterized by a relative abundance of quartz, and a paucity of carbonate in the 1-2 mm sand fraction.

Glaciolacustrine silt and clay of the Ethel Lake Formation were deposited in proglacial lakes during the advance of the Ardmore Glacier. Till of Marie Creek Formation was deposited by the Ardmore Glacier, overtop the Ethel Lake Formation. The till is characterized by a relative abundance of carbonate rocks, mainly dolostone, in the silt-clay and 1-2 mm sand fractions.

Glaciofluvial sand of the Sand River Formation was deposited following the retreat of the Ardmore Glacier and during the advance of the Cold Lake Glacier.

The Grand Centre Formation consists of till and glacially displaced sediment deposited by the Cold Lake Glacier. The till is characterized by an abundance of igneous and metamorphic rock fragments in the 1-2 mm sand fraction.

Oxidized profiles on the surface of the till formations suggest that lengthy periods of weathering followed each major glacial episode.

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In a study of this magnitude and duration, it is understandable that many people have contributed towards its completion. I am firstly grateful to Dr. N. Rutter, not only for agreeing to serve as my supervisor, but also for his patience in awaiting the first manuscript. I am indebted to the management of the Natural Resources Division of the Alberta Research Council, in particular Drs. R. Green, K. Babcock, and G. Mossop, for their financial and scientific support, as well as their encouragement and confidence.

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I. INTRODUCTION

The recent expansion of the heavy oil industry in east-central Alberta has demonstrated the need for new and varied sources of geologic construction material, as well as an understanding of the geotechnical and hydrogeologic properties of the overburden. In anticipation of this need for surface and subsurface information, the Alberta Geological Survey initiated a study in 1976 of the Quaternary deposits which overlie the heavy oil sand deposits in the Sand River map area, NTS 73L.

The main objective of the project is to examine the lithologic properties, thickness, distribution, and genesis of the subsurface deposits to establish the Quaternary lithostratigraphy. To accomplish this, a dry auger drilling program and a surficial geology mapping program were initiated. The data derived were supplemented by the existing data from water-well drillers' records, oil company geophysical logs, and studies by previous workers (Gold, 1978; Yoon et al, 1974). Of the various analyses performed on the samples from these testholes, two properties, matrix texture and composition of the very coarse sand fraction, prove to be most effective for differentiating units in the glacial sequence. Using these compositional properties, in conjunction with the characteristic geophysical log signatures of individual units, the glacial and non-glacial stratified units were correlated throughout the map area.

Names have been assigned to the stratigraphic units, following the format defined by the Canadian Society of Petroleum Geologists Lexicon Committee for naming geologic units. An attempt has been made to correlate these units with those previously defined in Saskatchewan (Christiansen, 1968).

The results of this study indicate that four major glaciations have occurred within the Sand River map area. Datable material was not found within any of the units, consequently the ages of these glaciations are unknown.

A. Location and Geography of the Sand River Map Area

The Sand River map area is located in east central Alberta (latitude 54-55 degrees, longitude 110-112 degrees); the Alberta - Saskatchewan provincial boundary forms the eastern margin (Figure 1). It encompasses approximately 14,000 sq. km. (5500 sq. mi.) including townships 58 to 69 and ranges 1 to 13, west of the 4th meridian. Alberta

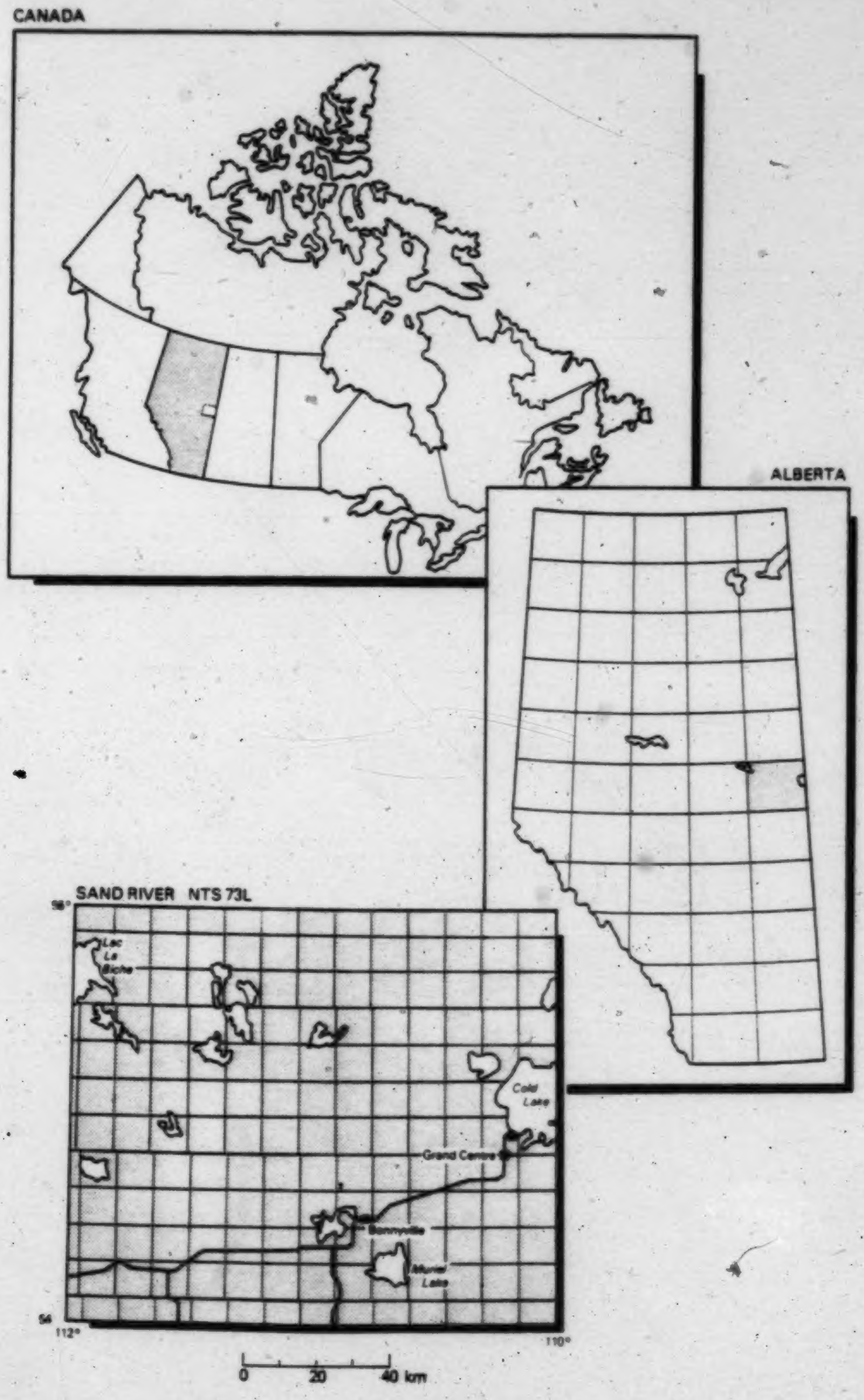

CANADA
ALBERTA
SAND RIVER NTS 73L
55°
Lac La Biche
Cold Lake
Grand Centre
Bonnyville
Muriel Lake
54
112°
110°
0
20
40 km

Figure 1. Location map of the Sand River area.

Highways 28, 28A and 36 connect the major communities, the largest being the towns of Bonnyville in the central part of the map area, Lac LaBiche in the northwest, and Grand Centre and Cold Lake in the northeast.

Road access is generally good in the agricultural central and western parts of the map area, but poor to non-existent in the north. Approximately 2300 sq. km. (900 sq. mi.), defined by townships 67 to 69, ranges 1 to 9 in the northeastern part of the map area, are used by the Department of National Defense as an air weapons testing range and are inaccessible to the general public. Mapping within this area was done by way of helicopter traverses.

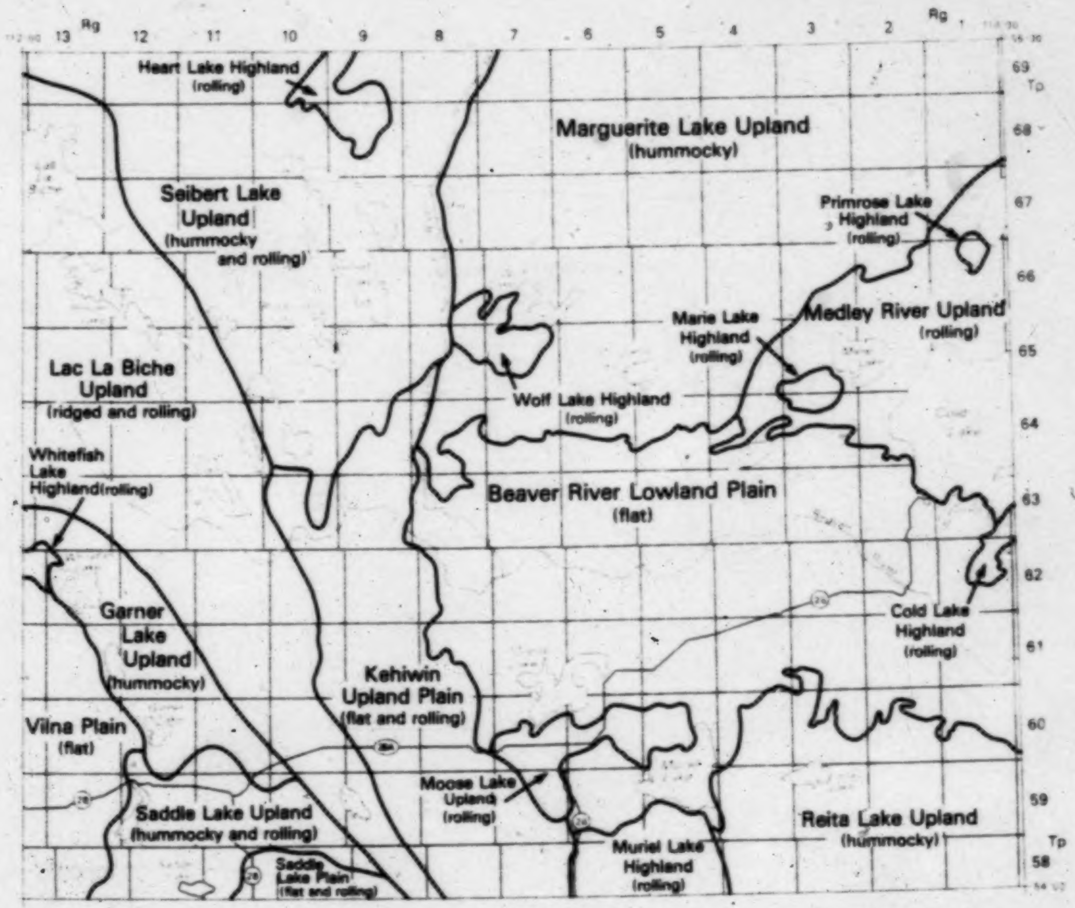
B. Physiography of the Sand River Map Area

Physiographically the Sand River map area lies within the Eastern Alberta Plains and the Mostoos Hills Upland (Atlas of Alberta, 1969). The Mostoos Hills Upland lies in the northeast part of the map area at an elevation above 600 m (2000 feet). The Eastern Alberta Plains lies in the west and south parts of the map area at an elevation below 600 m (2000 feet). A subdivision of these major physiographic units is discussed below (Figure 2).

Most of the map area is characterized by glacial terrain with a flat to hummocky topography (Andriashek and Fenton, 1983). Outwash plains form a relatively small component of the physiography and are found mainly along the major meltwater channels. Extensive lacustrine plains are absent in the map area.

The area includes numerous lakes that are connected by a poorly integrated drainage system. The largest of these include Cold Lake in the east, Muriel Lake in the south, Pinehurst, Seibert, Wolf, Touchwood and Spencer Lakes in the central part, and Lac LaBiche and Beaver Lakes in the northwest (Figure 2). Many of the lakes have clear water and sandy beaches, which make the area a favoured recreation site in the province.

Drainage is confined essentially to the Beaver River and the Sand River. The Beaver River, the larger of the two, drains eastward from Beaver Lake and forms part of the Churchill River drainage system. The Sand River drains south from its headwaters north of the map area and joins the Beaver River in the central part of the study area.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Heart Lake Highland (rolling)
Marguerite Lake Upland (hummocky)
Seibert Lake Upland (hummocky and rolling)
Primrose Lake Highland (rolling)
Marie Lake Highland (rolling)
Medley River Upland (rolling)
Lac La Biche Upland (ridged and rolling)
Wolf Lake Highland (rolling)
Whitefish Lake Highland(rolling)
Beaver River Lowland Plain (flat)
Garner Lake Upland (hummocky)
Cold Lake Highland (rolling)
Kehiwin Upland Plain (flat and rolling)
Vilna Plain (flat)
Moose Lake Upland (rolling)
Saddle Lake Upland (hummocky and rolling)
Reita Lake Upland (hummocky)
Muriel Lake Highland (rolling)
Saddle Lake Plain (flat and rolling)

Figure: 2 Physiography of the Sand River area.

For the convenience of geologic discussions, the two large physiographic units of the map area have been subdivided on the basis of relief, elevation and morphology (Figure 2).

The lowest of these physiographic units, the Beaver River Lowland Plain, is situated in the eastern part of the map area at an elevation generally less than 580 m (1900 feet). This unit is characterized by a flat to gently rolling till plain. The Beaver River drains eastward through the unit and locally, fluvial or lacustrine plains are found adjacent to the river.

South of Cold Lake, along the northeastern margin of the Beaver River Lowland Plain, lies the Cold Lake Highland (Figure 2). This unit ranges in elevation from 580 m (1900 feet) to about 670 m (2200 feet). The highland is characterized by high relief rolling terrain and forms an abrupt scarp along its southern edge.

The Medley River and Marguerite Lake Uplands form the northern margin of the Beaver River Lowland Plain (Figure 2). The Medley River Upland lies at an elevation between 580 m (1900 feet) and 610 m (2000 feet) and is characterized by gentle to high relief rolling terrain. The Medley River drains southward through this unit.

Lying within the Medley River Upland are two small but conspicuous physiographic units; the Marie Lake and the Primrose Lake Highlands. The Marie Lake Highland ranges in elevation from 610 m (2000 feet) to about 650 m (2125 feet). The unit is characterized by high relief, rolling to hummocky terrain. The Primrose Lake Highland lies at an elevation ranging from 610 m (2000 feet) to about 680 m (2225 feet) and is characterized by terrain that forms a pronounced knob in the local topography.

The Marguerite Lake Upland ranges in elevation from 580 m (1900 feet) to as high as 730 m (2400 feet) in the north part of the map area. The unit is bounded in the west by the Sand River and in the east by the Medley River Upland. It is characterized by hummocky terrain with numerous wetlands. Within the Marguerite Lake Upland lies a smaller unit, the Wolf Lake Highland (Figure 2). This highland ranges in elevation between 640 m (2100 feet) to about 730 m (2400 feet). It is characterized by ridged terrain in the northwest part of the unit and by rolling terrain in the central and east part. The Wolf Lake Highland is very conspicuous as one approaches from the south.

The Reita Lake Upland forms the southeastern margin of the Beaver River Lowland Plain. The unit ranges in elevation from 580 m (1900 feet) to about 700 m (2300 feet). It is characterized by moderate to high relief, hummocky to rolling terrain. The unit is bounded in the west by a misfit channel, herein called the Muriel Lake Channel, that once drained southeast of Muriel Lake.

The Muriel Lake Highland lies west of the Reita Lake Upland (Figure 2). It ranges in elevation from 580 m (1900 feet) to 800 m (2600 feet). It is characterized by rolling terrain. The unit is bounded by two misfit channels; the Kehiwin Channel in the west, and the Muriel Lake Channel in the east.

The Moose Lake Upland lies northwest of the Muriel Lake Highland and forms the extreme southwest boundary of the Beaver River Lowland Plain (Figure 2). The upland lies between an elevation of about 580 m (1900 feet) to 610 m (2000 feet). It is characterized by rolling terrain.

The western boundary of the Beaver River Lowland Plain is defined by the Kehiwin Upland Plain (Figure 2). The unit lies at an elevation that ranges from 580 m (1900 feet) to as much as 640 m (2100 feet). It is characterized by flat to rolling, glacially streamlined terrain. The Beaver River drains eastward through the north part of this unit.

The Lac LaBiche Upland lies west and north of the Kehiwin Upland Plain (Figure 2). The unit ranges in elevation from 640 m (2100 feet) to about 670 m (2200 feet) and is characterized by ridged to rolling, glacially streamlined terrain oriented in a northwest-southeast direction.

The Lac LaBiche Upland is bounded along its southwest margin by the Garner Lake Upland, and along its northeast margin by the Seibert Lake Upland (Figure 2). The Garner Lake Upland lies at an elevation ranging between 610 m (2000 feet) and 640 m (2100 feet) and is characterized by hummocky terrain, with the size of the individual hummocks decreasing southeastward from about 1 sq. km and 30 m high, to about .1 sq. km and 3 m high. Adjacent to the northwest part of the Garner Lake Upland lies the Whitefish Lake Highland, a unit characterized by high relief, ridged to rolling terrain. The unit ranges in elevation from 610 m (2000 feet) to 670 m (2200 feet) (Figure 2).

The Sand River forms the eastern boundary of the Seibert Lake Upland (Figure 2). The upland ranges in elevation from 610 m (2000 feet) along its southern margin to as high as 760 m (2500 feet) near Heart Lake, though generally it lies below 670 m (2200 feet). The upland is characterized by large scale, features which form a hummocky to rolling terrain. In some places adjacent to the Sand River, landforms have a glacially streamlined north-south orientation. The Heart Lake Highland is located within the north end of the Seibert Lake Upland (Figure 2). The highland ranges in elevation between 760 m (2500 feet) and 850 m (2800 feet) and is characterized by rolling terrain.

The southwest corner of the map area is characterised by lower relief landforms with differences in morphology. These differences define two plains, the Vilna and the Saddle Lake Plains, which are separated by a hummocky to ridged upland, the Saddle Lake Upland (Figure 2). The Vilna Plain lies southwest of the Garner Lake Upland and extends west of the map area. The unit lies at an elevation that ranges between 640 m (2100 feet) and 670 m (2200 feet), and is characterized by flat to low relief rolling terrain. It is bounded along its eastern margin by a scarp of the Saddle Lake Upland. The Saddle Lake Plain has a transitional boundary with the southeastern edge of the Saddle Lake Upland. The plain is characterized by flat to rolling, low relief terrain with a series of isolated ridged hummocks, which have an east-west orientation.

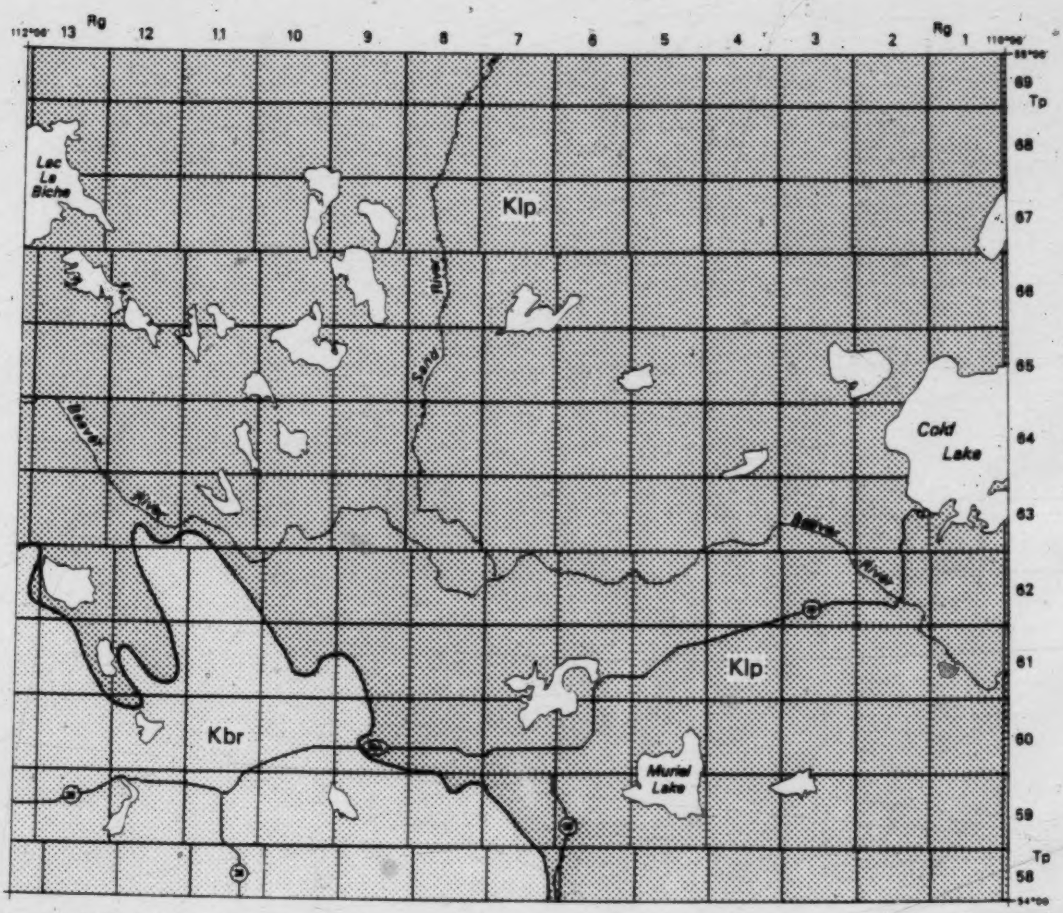
C. Bedrock Geology

The bedrock in the Sand River map area consists of two Upper Cretaceous formations: the Lea Park Formation (Allan, 1917) which underlies the entire map area, and, the Belly River Formation (Dawson, 1883) which overlies the Lea Park Formation in the southwest corner (Figure 3).

Over most of the east-central part of the province the uppermost Lea Park Formation consists predominantly of grey marine shale which contains varying amounts of silt and sand, ironstone concretions, and bentonite layers (Hume and Hage, 1941, Shaw and Harding, 1949). The thickness of the formation ranges between 135 m and 245 m and thickens to the northeast

> "as a result of successive lensing-out of several deltaic sand members of the Belly River formation" (Shaw and Harding, 1949, pg. 488).

In places the upper part has a yellow-brown color (Allan, 1917), but where it was recognized in the testholes in the Sand River map area, it is unoxidized dark grey (5Y 3/1


112°00'
Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00'
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69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00'
Lac La Biche
Klp
Sand River
Beaver River
Cold Lake
Beaver River
Klp
Kbr
Muriel Lake

from geological Map of Alberta, R. Green, 1972

1:750,000

Kbr	BELLY RIVER FORMATION: grey to greenish grey, thick-bedded feldspathic sandstone; grey clayey siltstone, grey and green mudstone; concretionary ironstone beds; nonmarine
Klp	LEA PARK FORMATION: dark grey shale; pale grey, glauconitic, silty shale with ironstone concretions; marine

Figure: 3 Bedrock geology of the Sand River area.

Munsell color scale). The formation is believed to outcrop along portions of the Kehiwin and Beaver River valleys, but in this study was recognized mainly from rotary and auger testhole samples, and electric log responses. Dry auger flite samples of the shale have a waxy appearance when cut with a knife, and commonly contain inclusions of lighter, buff-colored non-calcareous clay. The formation is generally soft and poorly lithified; and has a brittle to crumbly structure on the auger flites. The upper part of the formation is relatively easy to penetrate with an auger drill. This is one reason why the formation is difficult to differentiate from unlithified Pleistocene deposits of fine-grained lacustrine or fluvial sediment.

The top of the Lea Park Formation is gradational and conformable with the overlying Belly River Formation. The marine shale of the Lea Park Formation interfingers with the deltaic sand of the Belly River Formation and the contact is described as "stair-stepped" (Shaw and Harding, 1949 pg.488). In the east-central part of the province the Belly River Formation consists of an interfingering succession of marine shale and deltaic sand which are differentiatied into a number of members (Shaw and Harding, 1949). As an undivided formation, the Belly River Formation consists of:

> " a series of gray to brownish gray to greenish gray, argillaceous, bentonitic sand closely interbedded with brownish gray to gray, carbonaceous shales and silts. Thin carbonaceous layers are characteristic of the normal facies. Thin coal seams characterize the continental to marine transition facies." (Shaw and Harding, 1949, pg 491).

The formation is about 210 m thick near Edmonton but pinches out to the northeast in an interfingering, conformable contact with the underlying Lea Park Formation.

In this study, sandstone of the Belly River Formation was not recognized in outcrop nor within any of the auger testholes. The difficulty in recognizing Belly River Formation in the west is attributed firstly to its gradational contact with the Lea Park Formation and secondly, to the similarilty of the petrologic composition of the sand, compared with the sand composition of the overlying unit 1 of the Empress Formation. As well, glacial thrusting has displaced large masses of sandstone, shale, and coal of the Belly River Formation in the southwest corner of the map area, and it is difficult to be certain if the formation is in situ when encountered within a testhole, or, if it is an erratic. This is particularily a problem in the Kikino and Beverly valleys where as much as 60 m of the Belly River Formation are known to have been glacialy displaced and deposited within the valleys.

Because of the difficulty in establishing the contact between Lea Park Formation and Belly River Formation in the Sand River map area, the contact which is shown in Figures 8 and 9 is chosen from Green's boundary on the Geology Map of Alberta (1972). This contact is believed to dip to the southwest with a slope of about 4 m per km (20 feet per mile).

II. BEDROCK TOPOGRAPHY AND BURIED VALLEYS

A. Introduction

During the Laramide orogeny in western Alberta, uplift produced a regional slope which drains northeast through the plains of central Alberta. The drainage and erosion which followed from the Eocene through to the Pliocene, removed a significant amount of the Upper Cretaceous sediment, forming deep, broad valleys with intervening bedrock uplands. In places, particularily in the western and northern parts of the province, these uplands were mantled by thick fluvial gravel. The extent of this gravel-cap was minor to non-existant in the east-central part of the province, and the erosion produced large scale landforms of exposed soft Cretaceous bedrock.

Within the Sand River map area the tops of these bedrock landforms are mapped at an elevation as high as 650 metres in the north-central part (Figure 4). Drainage from these uplands was channeled into two major bedrock valleys, the Beverly and Helina Valleys. The bedrock surface lies at its lowest elevation within the Helina Valley, about 425 m along the eastern edge of the map area. During Pleistocene time, meltwater from a number of glacial advances eroded additional valleys into the bedrock surface. Glacial and stratified sediments now mask most of this underlying bedrock topography.

B. Previous Work

Numerous studies of the bedrock topography and buried channels have been done both within and surrounding the map area. Stalker (l960, 1967) conducted the recent studies in central Alberta and mapped the buried North Saskatchewan Valley near Edmonton. The name of this valley was changed to the Beverly Channel by Carlson (1966) in his detailed map of the bedrock topography in the Edmonton area. Borneuf (1973) mapped the Beverly Channel in the the east part of the Tawatinaw map area and extended the channel into the southwest corner of the Sand River map area. Farvolden (1963a) prepared a bedrock topography report in the Edmonton-Red Deer area and defined two major buried valleys which extend into the south part of the the Sand River study area: the Vegreville and the Vermilion Valleys. These two channels were more clearly defined by Carlson and Currie (1975) in the bedrock topography map of the Vermilion map area.

Christiansen and Whitaker (1974) mapped the bedrock topography and buried valleys directly east of the study area in the Waterhen map area of Saskatchewan. They show two buried valleys entering the Sand River map area: the Bronson Lake Valley in the south east corner, and the Hatfield Valley which is believed to enter beneath Cold Lake.

The first major study of buried valleys in the Sand River map area was done by Yoon and Vander Pluym (1974) who mapped the Beverly Channel and two other major buried valleys, the Helina and Kikino Valleys. Gold (1978) later defined the stratigraphy and history of the deposits within these buried valleys. More recently, a 1:250,000 scale bedrock topography map of the Sand River area was produced by a joint project between the Alberta Geological Survey of the Alberta Research Council and Alberta Environment (Gold, et al, 1983). A preliminary report to accompany that map is currently on open file with the publication office of the Alberta Research Council (produced by L.D. Andriashek). Much of that report forms the basis for the description of the bedrock topography which follows.

C. Buried Preglacial Valleys

The major preglacial valleys in the map area were formed by rivers which flowed east and northeast from the Rocky Mountains. These valleys are generally broad, with low gradients and low walls, suggesting a lengthy period during which downcutting and meandering occurred. Sediment on the floors of these valleys consists of sand or gravelly sand which is composed predominantly of quartzite and chert clasts derived from the Cordillera and local bedrock. Granitic clasts from the Canadian Shield are absent. Two major buried preglacial valleys and their associated tributaries are present within the study area: the Helina and the Beverly Valleys.

Helina Valley and Tributaries

The Helina Valley (Yoon and Vander Pluym, 1974) is the largest buried valley in the map area (Figure 4). It enters the northwest corner of the study area beneath Lac LaBiche, trends essentially southeast to Tp 63, Rg 8, and then swings northeast to Tp 65, Rg 4, extending beneath Cold Lake and ultimately joining the Hatfield Valley in Saskatchewan (Whitaker and Pearson, 1972). The contour lines show that the central and east segment

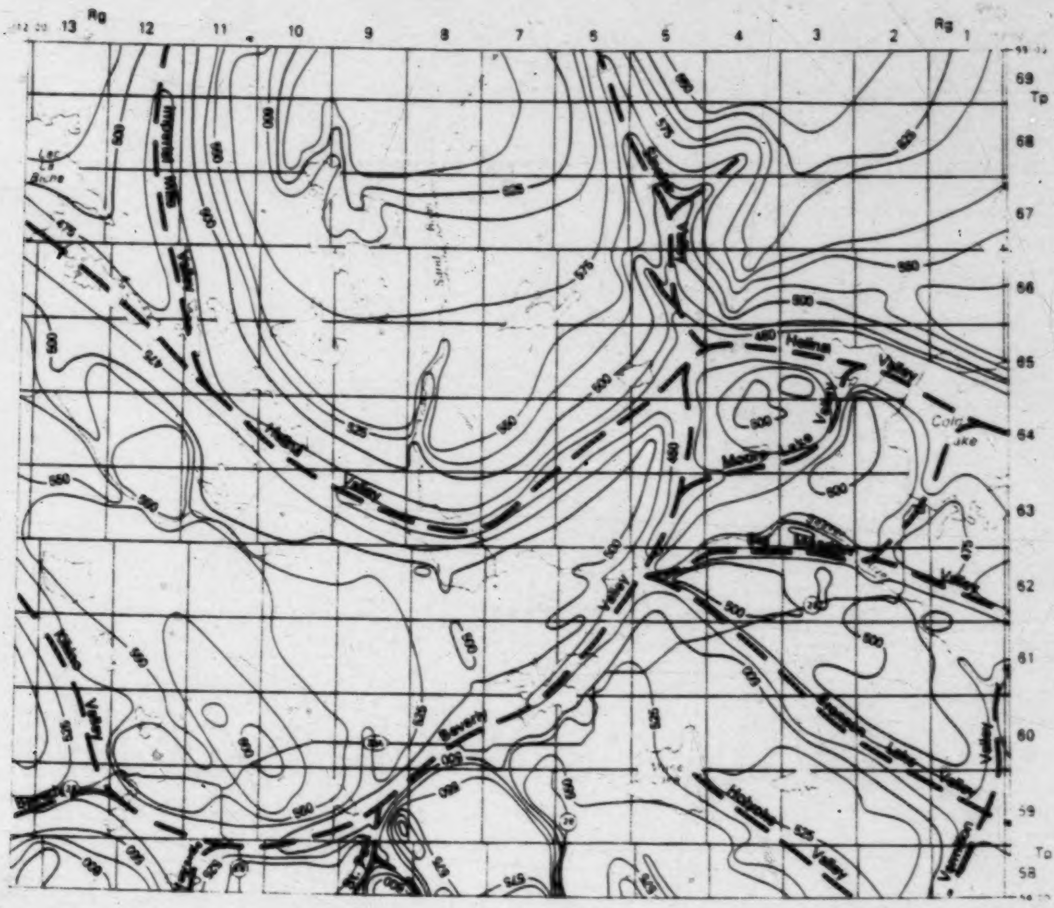

Rg
13
12
11
10
9
8
7
5
4
3
2
1
Tp
69
68
67
66
65
64
63
62
61
60
59
58
Imperial Mills Valley
Helina Valley
Moody Lake Valley
Beverly
Hollister Valley
Vermilion
Valley
Sand
Lac La Biche
Cold Lake
500
525
550
575
600
625

Figure: 4 Bedrock topography of the Sand River area.

Contours in metres

of the valley slope northeast, whereas the northwest segment slopes northwest (Figure 4). The valley is relatively wide, ranging from about 8 km to as much as 12 km in places. The depth ranges from 35 to 65 m but averages about 50 m. In places both depth and width are difficult to determine, primarily because the valley walls are poorly defined and the slopes are shallow (Figure 4). The northeast slope of the valley falls 40 m in elevation, over about 150 km, yielding a gentle gradient of about .25 m per km.

Three tributaries of the Helina Valley are recognized in the map area; the Imperial Mills, the Sinclair, and the Vermilion Valleys (Figure 4). The Imperial Mills Valley enters the north part of the map area in Tp 69, R 12, and trends south for a distance of 40 km to join the Helina Valley in Tp 65, Rg 11 (Figure 4). The north end of the valley extends into the Winnefred Lake map area where it is believed to join the buried Wiau Valley (Gold, pers. comm.). The estimated width of the valley ranges between 4.5 and 6.5 km but there are insufficient data along the east flank of the valley to derive an accurate figure. Similarly, the depth of the valley could not be determined. A broad low in the present land surface near the settlement of Imperial Mills is the only topographic expression of the valley.

The Sinclair Valley is located east of Wolf Lake in the northeast corner of the map area (Figure 4). The valley enters the northern part of the map area in Tp 69, Rg 6, and slopes southeast for a distance of about 45 km to join the Helina Valley in Tp 65, Rg 4. The width of the valley ranges between 8 and 10 km, and the depth between 40 and 70 m. The gradient at the southern end of the valley is calculated to be about 1 m per km.

The Vermilion Valley (Carlson, and Currie, 1975), is considered to be a tributary of the Helina-Hatfield Valley system in the map area, though the junction of the two valley systems has not been mapped (Figure 4). The valley enters in Tp 58, Rg 1, and slopes northward for a distance of about 30 km to Tp 61, Rg 1, where it extends beyond the map area. The valley is believed to join the buried Hatfield Valley in Saskatchewan. The estimated width of the Vermilion Valley ranges between 3 and 5 km, and the depth is at least 35 m. The data are insufficient to be able to calculate the gradient of the valley within the map area, but Yoon et al (1974) calculated a gradient of 1.7 m per km at the head of the valley in the plains region southwest of the study area (Carlson, and Currie, 1975).

Beverly Valley and Tributaries

The Beverly Valley is the second largest buried valley in the map area (Figure 4). The valley enters in Tp 59, Rg 14, and slopes essentially northeast to Moose Lake. From there the valley trends north to Borque Lake in Tp 65, Rg 5, where it merges with the Helina Valley. The width of the valley ranges between 5 and 8 km, and the depth between 45 and 60 m. The valley is generally narrower and has steeper walls than the Helina Valley. (Figure 4). The elevation of the floor of the valley decreases about 60 m from west to east with a gradient of about .5 m per km.

Three preglacial tributaries of the Beverly Valley have been recognized in the study area: the Vegreville, the Kikino, and the St. Paul Valleys (Figure 4). The Vegreville Valley enters near Saddle Lake in Tp. 58, Rg 12, and extends northward for a distance of about 8 km to join with the Beverly Valley in Tp 58, Rg 11. In this segment the Vegreville Valley begins to merge with the Beverly Valley and thus is wide and poorly defined. South of the study area Farvolden (1963a) describes the valley as having narrow, steep banks and a gradient of 1.3 m per km. Yoon and Vander Pluym (1974) later calculated the width to range between 2.5 and 6 km. Within the map area drill records indicate a valley depth of about 30 m.

The Kikino Valley enters in Tp 62, Rg 14, and extends southeast for a distance of about 30 km to join with the Beverly Valley in Tp 59, Rg 13 (Figure 4). The Kikino Valley is narrower than the Beverly Valley and, except for the area north of Bonnie Lake where the width ranges between 6 and 8 km (Figure 4), the average width is between 3 and 5 km. The depth of the valley averages about 30 m (Yoon and Vander Pluym, 1974) but deepens to about 45 m near the confluence with the Beverly Valley, and to about 90 m near Whitefish Lake. Northwest, in the Tawatinaw map area, the valley slopes gently to the northwest with a gradient of about .5 to 1 m per km (Yoon and Vander Pluym, 1974). Though the gradient could not be determined within the map area, the valley is considered to slope southeast towards the Beverly Valley.

The St. Paul Valley consists of two branches which enter in the southwest part of the map area and which merge to join with the Beverly Valley at Tp 59, Rg 9 (Figure 4). Both branches are relatively narrow and shallow, ranging in width between 1 and 1.5 km, and in depth about 25 m. The west branch has a relatively steep gradient estimated to be about 3 m per km.

D. Buried Glacial Valleys

Although segments of the preglacial valleys probably served to drain glacial meltwater, there are a number of buried valleys in the map area which are considered to have been formed by rivers in contact with, or near a glacier margin. These valleys are recognized by the following features:

1. most, though not all, of the valleys are oriented in a direction which is orthogonal to the regional drainage (ie. oriented in a general northwest-southeast, rather than northeast, direction),
2. the valleys are generally narrow and have steep walls, indicating that they served as a drainage system for a short period of time, and
3. stratified sediment on the floor of the valleys contains abundant clasts derived from the Canadian Shield, which indicates a Laurentide glacial source.

At least four major buried glacial valleys have been recognized, all within the eastern part of the map area. These are,the Moore Lake Valley, which lies west of Cold Lake in Tp 64, Rgs 3-4, the Big Meadow Valley, the Holyoke Valley, and the Bronson Lake Valley (Figure 4).

The Moore Lake Valley extends from Tp 63, Rg 5, where it joins the Beverly Valley, northeast about 30 km to Tp 65, Rg 2, where it joins the Helina Valley (Figure 4). The north end of the valley is narrow, about 2 to 3 km wide, but it broadens in the west. Most of the valley lies at a higher elevation than the Beverly Valley and averages about 35 m in depth. The western end however is very deep, at least 60 m, and lies at a lower elevation than the nearby preglacial Beverly Valley.

The Big Meadow Valley lies within the eastern part of the Beaver River Lowland Plain and joins with the Beverly Valley in Tp 62, Rg 5, at essentially the same junction as the Bronson Lake Valley (Figure 4). From here the Big Meadow Valley slopes east to Tp 62, Rg 2 at which point it divides; one branch swings northeast to join the Helina Valley beneath Cold Lake, and the other branch continues east, likely joining the Vermilion Valley in Saskatchewan. The average width of the valley is narrow, ranging from 1 to 1.5 km at the west end, but widens to about 3 km near the junction with the Helina Valley. The depth of the valley ranges from 14 to 23 m. The data are inconclusive to determine either the gradient or flow direction.

The Bronson Lake Valley extends southeast from its junction with the Beverly Valley in Tp 62, Rg 5, about 55 km to Tp 59, Rg 1 (Figure 4). From here, the valley appears to intersect the Vermilion Valley, and extends east into Saskatchewan, where it was first mapped (Whitaker and Pearson, 1972, Christansen and Whitaker, 1974). The width of the valley narrows from about 3 km in the central segment to about 1.5 km near the junction with the Beverly Valley. The depth of the valley ranges between 30 to 43 m, and within the map area the estimated gradient is about 1.3 m per km to the northwest, towards the Beverly Valley.

The Holyoke Valley may originate beneath Muriel Lake in Tp 59, Rg 5, and extends southeast approximately 38 km to Tp 58, Rg 3 where it exits the map area (Figure 4). The western end of the valley has not been determined however, and may join with the Beverly Valley. Similarily, the eastern end of the valley is not cleraly defined, though it may merge with the preglacial Vermilion Valley beneath Frog Lake in Tp 56, Rg 2. The estimated width of the valley ranges from about 1 to 2 km, and the depth from 15 to 20 m. Due to the paucity of data from the valley, and the gradient is unknown.

E. Origin

Preglacial Valleys

Helina Valley and Tributaries

The wide, broad nature of the Helina Valley, combined with its shallow slope suggests that the valley was eroded over a great period of time. The valley bottom sediment, as discussed in greater detail in the description of the Empress Formation, consists of sand and gravel composed almost entirely of quartzite and chert clasts derived from the Rocky Mountains. This demonstrates a fluvial, preglacial origin of the valley. In fact, Gold (1978) suggests that the Helina Valley may have contained the preglacial Athabasca River.

The reversed opposite gradients at either end of the floor of the Helina Valley, shown in Figure 4, are evidence that flow within the valley was in opposite directions during the history of the valley. This suggests that stream capture of the Helina drainage system likely occurred during its development. It is unknown which fluvial system caused this capture.

The Vermilion and Sinclair Valleys, and possibly Imperial Mills Valley as well, represent tributaries which developed on the Helina drainage system. The Vermilion Valley has its headwaters within the Edmonton map area in the plains region of central Alberta. Although the valley is probably a major tributary of the Helina system, the junction of the two valleys has not been clearly determined. It is likely that the two merge in Saskatchewan, directly east of the Sand River map area, but in the absence of data in that area, the Vermilion Valley could conceivably join the nearby Hatfield Valley instead. The relatively steep gradient of the Sinclair Valley suggests that it is a much younger tributary. Its headwaters are believed to be confined to the bedrock uplands north of the Helina Valley.

The origin of the Imperial Mills Valley is uncertain, however it may be a tributary of the Helina Valley. It is very broad and shallow, and it has a very shallow gradient, all of which suggest that it is more developed and therefore older than most of the other tributaries. The northern end of the valley likely joins the buried Wiau Valley (Gold, pers comm., Gold, 1983) and therefore serves to connect the Helina drainage system with the Wiau drainage system. In fact, the Imperial Mills Valley may represent stream capture which diverted flow from the Wiau Valley, rather than being a tributary confined solely to the Helina system. This is supported by the shallow gradient of the Imperial Mills Valley which suggests reversed or diverted flow could have occurred.

Beverly Valley and Tributaries

The origin of the Beverly Valley is almost certainly the preglacial ancestral drainage system of the present day North Saskatchewan River. This system has been mapped continuously as far west as the foothills of the Rocky Mountains (Stalker 1960; Farvolden 1963a; Carlson 1966, 1977). The valley bottom sediments, like those on the floor of the Helina Valley, are composed of fluvial sand and gravel composed of quartzite and chert derived from the Rocky Mountains. The presence of these deposits supports a preglacial origin of the valley.

Compared to the Helina Valley, the Beverly Valley is narrower, has steeper walls and has a steeper gradient, all of which suggests that it is less mature and therefore younger than the Helina Valley. In fact, the geometry of the confluence of the two valleys, shown in Figure 4, supports the hypothesis that the Beverly Valley can be considered to be a tributary of the Helina system. Segments of the Beverly Valley also functioned as a glacial or interglacial drainage system, but the valley is now completely buried by stratified and glacial sediment.

The Vegreville and St. Paul Valleys, and possibly the Kikino Valley, represent tributaries of the the Beverly Valley. Farvolden (1963a) mapped the headwaters of the Vegreville Valley in the plains region of the Vermilion map area, southwest of the study area. He believed that the stratified sediment at the base of the valley is Tertiary fluvial sediment which once capped the highlands adjacent to the channel.

Segments of the Vegreville Valley were also reoccupied by glacial or interglacial water. This is indicated by drill records and samples of a thick sequence (60 m) of stratified glaciofluvial sediment along the northern segment of the Vegreville Valley directly south of the Sand River map area (Fenton and Mougeot, in prep.).

The St. Paul Valley is also assumed to be a preglacial tributary of the Beverly Valley, however the composition of the basal stratified sediment has not been examined. Glacial sediment (till) from the first glaciation lies on the floor in parts of the valley. This is discussed in greater detail in the following description of the Bronson Lake Formation.

The Kikino Valley is considered to be a tributary of the Beverly Valley, although it, like the Imperial Mills Valley, also connects two major valleys, the Beverly and the Helina Valleys. Two possible explanations can be offered for its origin. Firstly, the Kikino Valley may represent a breach of the divide between the Beverly and Helina Valleys. Thus, it simply reflects stream capture from one system to another. The geometry of the junction of the Kikino Valley with the two major valleys suggests that drainage in the Helina Valley would have been captured by the Kikino Valley and diverted southeast into the Beverly Valley. This seems unlikely however, because the Helina Valley lies at a lower elevation and is a more mature system. If anything, the Beverly drainage system would be expected to be captured by the Helina system.

The second explanation seems more plausible. Gold (1978) believed that a southwest advancing glacier was responsible for blocking the drainage within the preglacial North Saskatchewan River. This caused the river to cut an ice marginal channel which redirected the regional drainage northwest towards Lac La Biche. Later, Gold and this author, during numerous discussions in the preparation of the bedrock topography map, offered another equally plausible explanation of the valley's origin. We suggest that the first glacial advance blocked the drainage in the Helina Valley to the north, causing the water to drain southeast and erode the Kikino Valley. The evidence proposed is twofold. Firstly, the geometry of the junctions of the Kikino Valley with both the Helina and Beverly Valleys suggests flow to the southeast rather than northwest (Carlson, 1977, and Figure 4). Secondly, the gradient of the southeast segment of the Kikino Valley slopes towards the Beverly Valley, and indicates a southeasterly flow at one time. The interfluve between the Helina and Beverly Valleys is relatively low within the eastern part of the Tawatinaw map area, and any drainage which was ponded within the Helina Valley could have easily breached this divide to flow southeast. After this southeastern segment of the valley was eroded, the northwest end of the Kikino Valley, where it joins the Helina Valley (Carlson, 1977), was eroded and down-cut. Possibly this occurred after the glacial margin retreated and when regional north-east drainage was re-established.

Late Preglacial - Early Glacial Valleys

Drainage within the preglacial valleys was severely disrupted and in some cases permanently altered by the first glacier in the map area, herein named the Cherry Grove Glacier. As the Cherry Grove Glacier advanced into the area, a series of valleys were eroded into the bedrock surface by both drainage diverted from the preglacial valleys, and by meltwater issuing from the glacial margin. The evidence for this is as follows.

Firstly, as previously discussed, some of the bedrock valleys are oriented generally orthogonal to the regional slope, which suggests erosional control by a glacial ice-margin. Secondly, borehole evidence suggests that drainage was diverted out of the major preglacial valleys, particularily the Beverly Valley, and along a series of newly created valleys on the bedrock surface. For example, drill records at the junction of the Big Meadow and Bronson Lake Valleys with the Beverly Valley, describe the valley floor sediment as composed of "preglacial" sediment, mainly quartzite and chert. Further east along these valleys, however, the lithologs describe the stratified sediment as containing granitic clasts, indicating a glacial source of sediment from the Canadian Shield. One explanation for this is that as the Cherry Grove Glacier advanced into the area, the preglacial regional drainage in the Beverly Valley was blocked and this diverted the drainage southeast, possibly along the ice-margin. This diversion eroded the Moore Lake, Big Meadow and Bronson Lake Valleys, all of which posssibly mark ice-front postions of the southwest advancing Cherry Grove Glacier. At the same time, preglacial sediment on the floor of the Beverly Valley was eroded and redeposited at the heads of the newly eroded valleys. Farther east along the valleys however, glaciofluvial sediment, containing granitic clasts, was deposited by glacial meltwater issuing from the glacier margin. The stratigraphic evidence (see descriptions of unit 3 of the Empress Formation and the Bronson Lake Formation) shows that this glaciofluvial sediment is overlain by glacial sediment (till) of the Cherry Grove Glacier, and this is presented as evidence that the valleys were eroded along ice-margins of the advancing Cherry Grove Glacier, rather than the retreat phase.

Further details of the history of these glacial valleys are presented more appropriately in the final section of this study which discusses the glacial events during the Quaternary.

III. QUATERNARY STRATIGRAPHY

A. Introduction

The Sand River map area is an accessible area of Alberta where the Quaternary sequence is diverse and well preserved. Although the sequence is generally thick (>50 m) compared to most areas in central Alberta, only the upper 10 m or so are exposed, primarily in river channel and road cuts. As a result, most of the stratigraphy defined here relies on subsurface data.

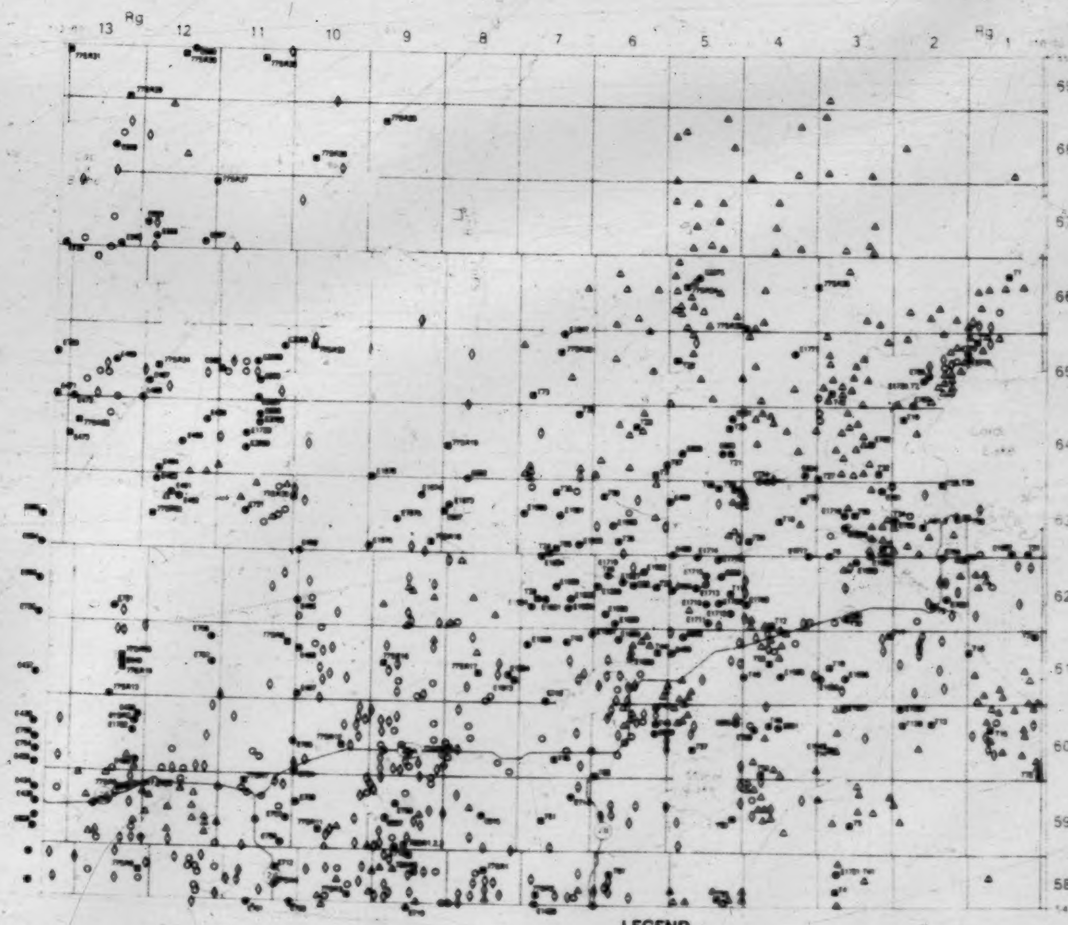
Eight Quaternary lithostratigraphic formations have been informally named for the Sand River area. Four glacial (till) and four non-glacial units are recognized, on the basis of stratigraphic position, differences in textural and lithologic composition, outcrop properties, and geophysical properties, including drilling characteristics.

Descriptions are given for each formation under separate chapter headings. These descriptions include: the type section, the lithologic, textural and lithic compositional properties, a summary table listing all Alberta Geological Survey testholes in which the unit is recognized, the extent and thickness in either the surface or subsurface (presented as distribution and isopach maps, as well as within cross-sections), the properties which differentiate the formation from the other formations (shown also in a summary table), the nature of contact with the underlying and overlying units, and, the origin. A history of the late Pliocene and Pleistocene geologic events in the Sand River area is proposed at the end.

B. Sources of Data

Four sources of subsurface data, ranked below in the order of their importance, are used in this study. These total more than 900 testholes drilled by government agencies, such as Alberta Environment and the Alberta Research Council, private oil companies and water-well drilling companies (Figure 5).

The primary source of data consists of lithologs and analyses of about 2500 samples collected from 110 dry-auger testholes drilled by the Alberta Geological Survey of the Alberta Research Council (herein referred to as the "Survey") in 1976 and 1977 (Figure 5). These testholes have two designations. Testholes labelled "T", followed by a


Rg
13
12
11
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Rg
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Tp
69
68
67
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Tp
58

LEGEND

Oil Well-with E-Log .... △
Alberta Environment Test Hole-with E-Log .... ●
Water Well-with E-Log .... ○
Water Well-without E-Log .... ◇
Alberta Research Council Test Hole .... ■

Figure: 5 Distribution map of testhole data.

number (for example, T32) were drilled in 1976, primarily in the east half of the map area. Testholes labelled "77SR", followed by a number, (for example, 77SR9) were drilled in 1977, mainly in the west half of the map area.

At each testhole samples were collected and logged at one metre intervals off a continuous-flite dry auger which, in most cases, was capable of penetrating to a depth of about 50 m. The samples were submitted to the laboratory for analyses, and the results were used, in conjuction with the lithologs,to differentiate and correlate the glacial (till) units. The lithologs of each testhole, as well as a table of the analytical data, are included in Appendix A. Because of the great thickness of the surficial deposits, the dry auger was capable of drilling through the complete Quaternary sequence in only 14 of the 110 testholes. Consequently, the Survey testhole data was useful for defining only the upper half to two-thirds of the stratigraphic sequence.

The next most important source of stratigraphic data is provided by Alberta Environment from their groundwater and buried channel investigations in the Sand River map area. These data consist of good quality electric logs, lithologs, and samples collected from drill cuttings and sidewall sampling. In this study the Alberta Environment testholes are designated by the capital "E", followed by a number (for example, E802).

Gold (1978) analysed the sidewall samples from 78 of these testholes in his study of the Quaternary stratigraphy in the buried channels in the Sand River map area. Some of Gold's analytical data, particulary the textural, very coarse sand composition, and matrix carbonate data, were used to define the lowermost glacial units in this study. One advantage of Gold's analytical data is that they are supplemented with electric logs. This enables correlations to be made with the electric log data from the water-well drillers.

Gold's data were not used to define the upper stratigraphic units for two reasons. Firstly, abundant data are available from this author's analyses of the Survey's dry-auger samples of the upper stratigraphic units. Secondly, there are significant differences in the values of some properties which Gold obtained, such as texture for example, compared to the values obtained in this study. For example, Gold records much lower clay content values for his tills, compared to those clay values determined for what appear to be the same tills in this study. Gold attributes most of the "suspect" absolute clay percentages to the long storage times of his samples, and to the "...consequent disaggregation problems associated with the sidewall samples used..." (Gold, 1978, page 19). Gold recognizes that his clay values are significantly lower than those determined by previous workers in the area (Pawluk and Bayrock, 1969). Consequently, Gold's textural data were used only for those lower units which were either not sampled, or sparsely sampled by the Survey. It must be kept in mind therefore that those textural values determined by Gold, which are used to define the lower till units in this study, likely represent minimum estimates of the clay content of the tills.

Gold's very coarse sand composition was also used to define the lower tills in this study. Gold divided his grain counts into five categories: basic igneous rocks, acid igneous rocks, undifferentiated quartz grains, carbonate rocks, and local sandstone and shale rocks. Unfortunately, the determination of the very coarse sand composition is a subjective technique and "absolute" percentages or values cannot be applied to a till. Nonetheless, most major lithologies are easy to recognize and the deviations from a "true" value are presumed to be small. Given this, the relative values of the coarse sand counts of Gold's tills can be compared to those values determined for the tills defined in this study. Although Gold's very coarse sand composition data were used primarily to characterize the lowermost tills in this study, the data were also useful in extending the correlations of the upper tills in those areas where the Survey did not collect data. Similarily, Gold's matrix carbonate data was also used to extend the correlations in areas of no data.

Testhole data from water-well drillers proved to be useful in extending the correlations of the stratigraphic units in those areas where analytical data is absent. These data consist of drillers' lithologs and, in some places, electric logs. Electric logs supplied by Chorney Drilling and Elk Point Drilling are the most useful because their logs are sensitive enough to record the differences in the electrical properties of the glacial (till) units.

Oil company geophysical logs provided the least useful source of stratigraphic data. Most of these logs are greater than 20 years old and were run for the purpose of mapping the top of the bedrock, as well as major lithologic changes in the bedrock such as shale versus sandstone. The logs are not sensitive enough to record differences in the glacial units but can be used to map the buried coarse sand and gravel units. As well, the upper 15 m of these testholes are cased and therefore the upper Quaternary sequence was not logged.

One exception to these early oil company logs consists of a series of structure testholes drilled throughout much of the province in the mid 1950's. These logs are recorded from the surface, and are of sufficient sensitivity to recognize differences in the the electrical properties of the glacial (till) and nonglacial units. These logs are, however, not differentiated from the earlier oil company logs in Figure 5.

C. Discussion of Methods

In this study the identification and differentiation of units within a stratigraphic sequence was accomplished using both laboratory data (Appendix A) and field observations (Appendix D). Emphasis has been placed on the differentiation and correlation of the glacial units (tills), to form the foundation from which the entire Quaternary stratigraphic sequence can be established. One reason tills can be regionally correlated from borehole studies is that the genesis of till can be determined more easily from borehole samples of till, than from borehole samples of stratified sediment. In the latter case, outcrop properties such as bedding, structure, and nature of contacts are commonly required to determine the origin of a stratified sediment.

Besides field descriptions of till outcrops and auger samples, a suite of laboratory analyses were perfomed on the samples in order to characterize and differentiate the different tills. The sequence of these analyses, beginning with sample collection and ending with computer generated data plots, are depicted in a flow chart in appendix D (Figure 62). The major analyses include: matrix texture and matrix carbonate content, composition of the very coarse sand (1-2 mm) fraction, clay mineralogy, moisture content and a minor amount of palynology.

For a given testhole the analytical data generated by the Survey's laboratory was displayed on computer generated graphs which plot the value of the property against depth. From these graphs the contacts between units are determined at those depths where distinct breaks or changes in the properties of the tills are evident. In some testholes it is found that at the contact between two units, all the properties change abruptly, and the contact is easily defined. Commonly though, the contact between two units is gradational in some or all properties, and only an approximate boundary can be defined. Generally, in these cases emphasis is placed on the very coarse sand composition, rather than texture, which can be more easily influenced by local factors, and the boundary is defined at the depth where the very coarse sand composition shows the greatest change.

Within a testhole the mean and standard deviation is calculated for the analyses of each property. These values enable units to be defined within a borehole, and attempted correlations are made with what are considered to be equivalent units in adjacent boreholes. When all the correlations are completed, a mean value, of all the means, from each testhole in which the unit is recognized, is determined. This mean of the means becomes a summary value which characterizes the till over the entire map area. Nearby geophysical logs, mainly electric logs, are then chosen so as to qualitatively calibrate the log responses with the analytical properties of the tills. This allows the electric logs to be used to correlate the tills in areas where analytical data are absent.

The following is a description of the properties examined, and an explanation of how these properties were applied to define the till stratigraphy.

A. Lithologic Properties

1. Color

   Color was used successfully in the Sand River map area to differentiate tills. Oxidized and unoxidized colors were recorded for outcrop faces as well as hand samples in a moist state, using Munsell color charts. Especially noted were buried oxidized horizons on the tops of units in both outcrops and testhole samples. In those places where an unoxidized till overlies an oxidized till, the oxidized horizon is considered to represent an exposed and weathered surface of the lower till.

2. Matrix Texture

   The determination of the till matrix texture is a method commonly applied in Alberta to characterize and differentiate tills (Westgate, 1969, Pawluk and Bayrock, 1969, Fenton and Dreimanis, 1976). This method proved to be successful in the Sand River area as well. In this study till matrix texture is defined as the percent total sand (2.00 mm - 0.063 mm), silt (0.063 mm .004 mm) and clay (less than .004 mm). Texture analyses were performed by the Alberta Geological Survey Quaternary Laboratory.

Their laboratory uses the hydrometer method to determine the clay content, but the method is a slightly modified version of the A.S.T.M. (1954) procedure for grain size analysis (Alberta Geological Survey Environmental Laboratory Manual, in prep.). The values obtained by the Survey's procedure are found to vary little from those obtained by the A.S.T.M. procedure, and save on the analytical time required. The fundamental difference between the two methods is that the Survey's laboratory uses a computer program to determine the silt-clay boundary, based on only the 2, 4, 8, and 24 hour hydrometer readings. This program then plots the clay curve from these four data points.

Dry sieves and an electronic balance are used to calculate the percentage of sand, using the conventional A.S.T.M. procedure. The 1-2 mm coarse sand fraction was extracted and stained with Alizurine red dye (to differentiate limestone from dolostone rock fragments, Friedman, 1959) specifically for two reasons: firstly, to determine petrologic composition, and secondly, to determine the amount of very coarse sand in the till matrix. It was found that in the Sand River area the percent of very coarse sand is a reliable tool for differentiating some of the tills, even those with similar bulk textures. This particle size is also one that can be easily seen in hand samples and thus enables a preliminary differentiation to be made in the field. Later, the quantitative value of the amount of very coarse sand in the till can be determined in the laboratory, and used to correct the initial field estimate.

3. Moisture Content

The moisture content of a till, expressed as a percentage of the weight of a sample, is found to vary proportionally with the amount of clay present in the matrix (testhole T-5, appendix A). The method involves weighing a moist till sample in the field, drying the sample in a temperature no higher than 70 degrees C and weighing the dry sample to determine the amount of water lost. The method is simple to perform and can be easily applied in the field to provide an estimate of the percent clay in a sample. However, the results of this technique were not used extensively in this study because the clay contents of the samples were calculated by the hydrometer method in the laboratory.

B. Petrologic and Mineralogic Properities

1. Petrology of the very coarse sand fraction

One method used to define and correlate tills from small, disturbed samples, such as testhole samples, involves the examination of the very coarse sand (1-2 mm) fraction to determine which bedrock types have been eroded and incorporated by the glacier (Gross and Moran, 1971, Fenton and Dreimanis, 1976,). This method can make it possible to determine the bedrock provenances as well as the source and direction of ice-flow.

By the process of trial and error, approximately 300 grain counts per sample proved to be sufficient to represent all rock types in the sample, and reasonably quick to count. For most of the tills in the Sand River area, the 1-2 mm sieve fraction, extracted from the textural analyses, provides about 300 sand grains.

The sand grains were separated into six petrologic categories: igneous and metamorphic rock fragments, quartz fragments, quartzite and quartz sandstone fragments, carbonate rock fragments, local rocks, and miscellaneous rocks. Following is a brief discussion of how these rock types are identified.

a. Igneous and metamorphic rock fragments

This category consists of those rock types which are derived primarily from the Canadian Shield. These consist mainly of granites, gneisses and metasedimentary rocks. The category includes both fine and coarse grained rocks and therefore it may contain Cordilleran volcanic rock fragments, which cannot be easily differentiated from the fine grained igneous rocks from the Shield. It is considered however that these Cordilleran igneous rocks represent only a very small percent of the total fine-grained portion. Furthermore, fine-grained igneous rocks constitute only a small percent of the total amount of igneous rocks, so that the misidentification of a fine-grained rock has little effect on the calculaton of the percent of the other rock types.

b. Quartz fragments

This category consists of almost all quartz grains irrespective of size, shape, roundness, or degree of transparency. It includes clear and milky quartz, quartz grains with impurities, and angular to rounded quartz. Two exceptions to this are:

1) quartz grains that have imprints of contact minerals showing cleavages, such as feldspar and hornblende, which indicate a probable igneous or metamorphic source and
2) single quartz grains that are spherical and which show quartz overgrowths; these grains are interpreted to have been derived from quartz sandstones.

c. Quartzite and quartz sandstone fragments

This category generally comprises a small percent of the total rock fragments in the tills of the Sand River map area. It includes both metaquartzites from the Rocky Mountains, and orthoquartzites from both the Rocky Mountains and the Athabasca Formation Sandstone in northeast Alberta. Fragments of Athabasca Formation orthoquartzites are identified by the following: the 1-2 mm grains are composed of smaller, silica-cemented quartz grains which form a moderately indurated "grape"cluster, and, iron staining commonly gives the grains a mauve to pinkish color. Fragments of the Rocky Mountain quartzites are commonly brownish to buff colored, and are composed of well-cemented to annealed grains of quartz. If the 1-2 mm metaquartzite grains are fractured, they commonly break across the indvidual smaller grains, rather than just along the grain boundaries. Otherwise, the 1-2 mm grains are commonly well-rounded. Also included in this category are individual,large quartz grains which are rounded and spherical and which show quartz overgrowths. These are interpreted to have been derived from an orthoquartzite.

d. Carbonate fragments

This category consists of two rock types: limestones and dolostones. There are two possible sources for the carbonate rock fragments in the tills in the Sand River area. The first is from preglacial fluvial sand and gravel, which lie on the floors of the major buried valleys, and which were eroded by the glaciers. These preglacial sediments contain quartzites, cherts, volcanics, and carbonates which were eroded and deposited by rivers flowing east from the Rocky Mountains. The second source is from Devonian carbonates which subcrop along the southwest margin of the Canadian Shield in northeast Alberta. In the Sand River map area it is believed that most of the carbonate rock fragments in the tills are derived from glacial erosion of the Devonian rocks in northeast Alberta. Only few, if any, of the carbonate rocks are considered to have been derived from the Rocky Mountains. The reason for this is that carbonate rocks are not as durable as quartzites and chert, and likely cannot survive the long transport distance along the river channels into eastern Alberta. If some carbonate rocks did manage to survive transport, likely the amount of these would be very small, compared to other rock fragments. Evidence to support this comes from recent work done on the composition of preglacial gravel in the Edmonton area, which lies west of this study area. The study shows that the gravel is composed of about 95% quartzite, 3% to 5% sandstone, about 1% conglomerate, and 0% to 1% carbonates (Edwards, 1984, pp. 220).

Limestone and dolostone are differentiated by their stained color, produced by Alizurine red S stain (Friedman, 1959) and by fragment appearance. When stained, limestones acquire a bright red color which contrasts to mauve or purple color of the dolostones. As well, limestone grains extracted from till samples are typically very rounded and commonly have an ovoid shape whereas dolostones grains have a cubic, angular shape, and a micrcrystalline, sugary texture.

e. Local rock fragments

This category consists of all locally derived bedrock fragments. In the eastern two thirds of the map area this includes shale and ironstone rock fragments derived from the Lea Park Formation. In the western third of the map area this category includes sandstone, siltstone, shale, coal and ironstone rock fragments derived from the Belly River Formation. Generally this category comprises a small percent of the rock fragments in the tills of the Sand River area.

f. Miscellaneous rock fragments

This category consists of chert, gypsum crystals, and unidentified rock fragments. It comprises generally less than one percent of a sample, although in some samples as much as 15 percent of secondary gypsum crystals may be present.

2. Matrix carbonate content

The matrix carbonate content of tills has been used successfully by a number of researchers as a means of characterizing and correlating tills (Christiansen, 1968, Fenton and Dreimanis, 1976). The method applied in this study uses the Chittick apparatus and procedure which was first designed and successfully applied to till analyses by Dreimanis (1962) and later adapted by Christiansen and Ross (1971).

Briefly, the Alberta Geological Survey's technique involves adding 10% HCL acid to the <.063 mm (silt-clay) fraction of the till matrix, and measuring the volume of CO2 gas released after the carbonates react to the acid. By measuring the volume of gas released as a function of time, the rate of reaction can be determined, and from this curve the percent of calcite and dolomite can be calculated (Christiansen, 1971).

Matrix carbonate determinations were done for only a number of selected reference samples of each till unit. This is because the method is relatively time-consuming and, because an estimate of the carbonate content of the tills can be provided by the carbonate content in the very coarse sand fraction.

3. Clay mineralogy

The X-ray diffraction method of determining the clay mineralogy (illite, kaolinite, montmorillonite, chlorite) of the tills was applied to only a number of reference samples of each unit (Appendix B). The technique was applied as a test to determine if the method was useful to differentiate the tills. For the most part the method was not successful and only in a few cases could the tills be differentiated (Appendix B, testhole T-6).

4. Miscellaneous studys

In many places within the Sand River map area the upper portion of the underlying bedrock of the Lea Park and Belly River Formations is composed of unconsolidated shale that is comparatively soft and which may be difficult to differentiate from clay deposits of Quaternary age. For a number of testhole samples of clay, a palynological examination was required to determine if the sediment was of Cretaceous marine origin, or Quaternary lacustrine origin. These analyses were performed by C. Singh of the Alberta Geological Survey who not only identified the species of the pollen and microflora, but also described their degree of preservation. A description of the degree of preservation is required because glaciolacustrine sediment could also contain reworked and redeposited Cretaceous pollen assemblages. Well preserved assemblages indicate that the sampled material likely was from in situ Cretaceous bedrock, and not from redeposited sediment.

C. Geophysical Properties

Geophysical properties prove to be very useful in correlating the stratigraphic units in the Sand River map area, especially in extending correlations into areas where samples cannot be collected. Typical geophysical logs available in the map area are electric logs which record the self-potential and resistivity responses of the different sediment types. In some of the testholes gamma-ray logs are also available.

At a number of locations the electric logs have been run in rotary testholes which are adjacent to the Alberta Geologicial Survey's auger testholes, and this enables a comparison between the log responses and the analytical data. This comparison allows representative log responses to be chosen for each of the tills defined by the analytical data, and these serve as standards for correlations in areas where analytical data are absent. In many areas however, auger testholes are either not located near enough, or, they are not drilled as deep as the rotary testholes, and the units must be identified entirely by breaks in the log signatures and correlated stratigraphic position.

The electric log responses of the units appear to be affected by a number of factors. Typically, coarse-grained deposits such as sand and gravel will have a high resistivity, especially if they are not water bearing. However, the addition of water provides dissolved salts which reduce the resistivity and this can produce a slight "kick" which is not indicative of a lithologic change. Fine-grained Quaternary deposits such as silt and clay generally show less variation in their signature; they always have a very low resistivity response. Lithified silt and clay deposits, such as marine shale of the Lea Park Formation, have an even lower resistivity and higher self-potential response. Presumably this reflects the consolidated and cemented nature of the bedrock.

For the most part the electric logs from the Sand River area are sensitive enough to detect not only gross differences in sediment type, such as gravel and clay, but also subtle differences in the lithologies of the till units. It appears that generally the logs record differences in the bulk textures of the units, though other factors appear to affect the logs as well. One of these is the presence, or absence, of fracturing within the tills. A high degree of fracturing at the top of a unit produces a higher resistivity than the lower unfractured portion. Other factors, such as a greater amount of carbonate cement within the till matrix also appear to contribute to a higher resistivity.

D. Quaternary Stratigraphic Sequence

The following, is a summary which defines the stratigraphic units, characterizes the properties used to differentiate and correlate the units, and relates the units to the geologic events in the Quaternary. The purpose of this summary is to aquaint the reader with the stratigraphic sequence in the Sand River area, prior to the detailed descriptions which follow. As well, an introduction to the units is useful to discuss the problems in differentiating and correlating these units.

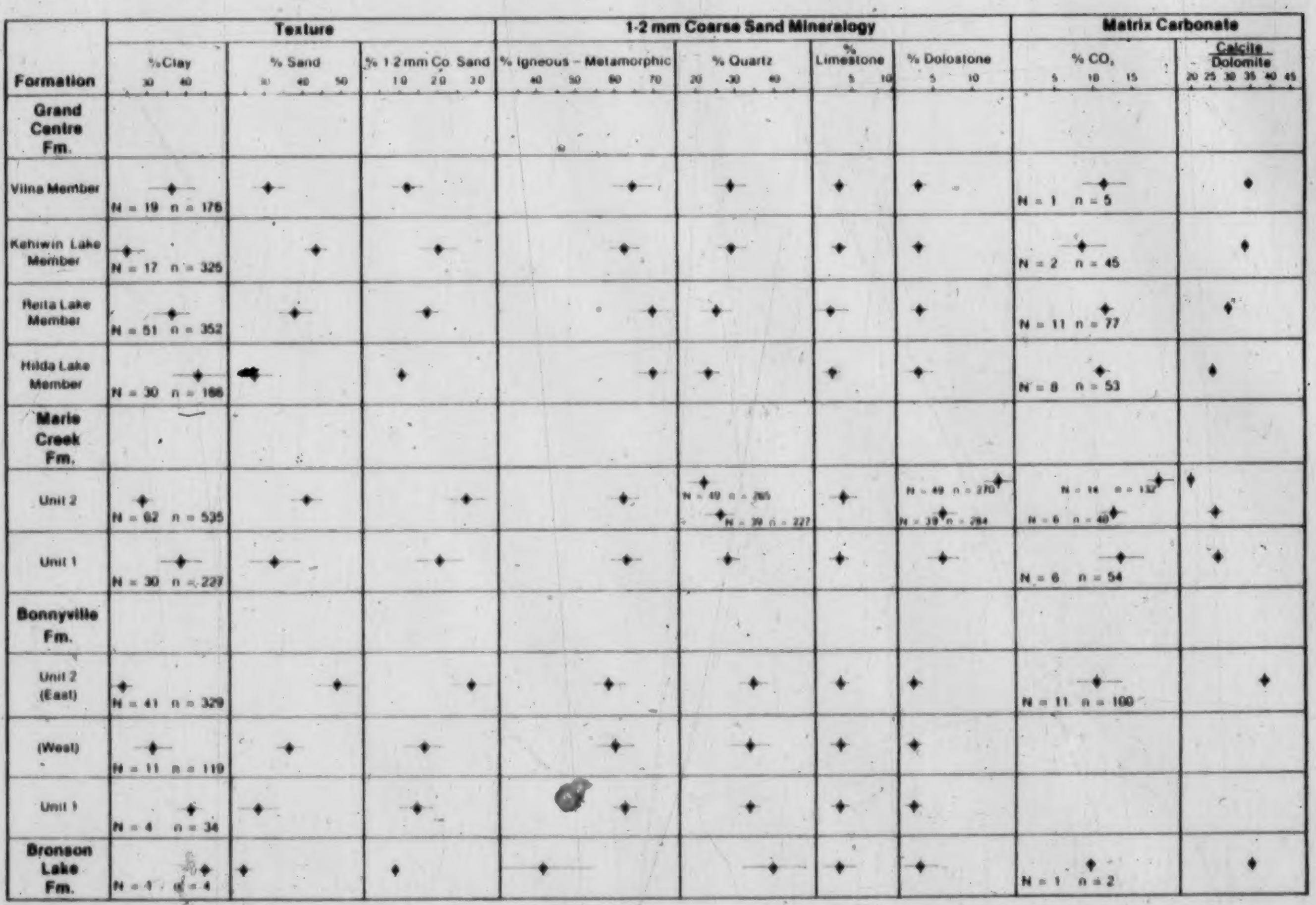
Three summary tables accompany this description. Table 1 represents the complete stratigraphic sequence, with the youngest formations or members listed at the top, and the oldest at the bottom. Table 2 summarizes the most characteristic properties of the units, and the ones most useful for correlating the units throughout the area. It is a graphic representation of the mean of all the mean values for the properties of each till unit at each testhole site. Lastly, Table 3 relates these stratigraphic units to the geologic events that most likely occurred during the Late Pliocene and the Pleistocene. There is no datable material for any of the formations in the Sand River area, consequently the absolute ages and duration of the proposed geologic events are unknown.

Preglacial Deposits

Table 1. Quaternary Stratigraphy of the Sand River Map Area

Formation	Description
Post Glacial and Recent Deposits	Stratified clay, silt, sand, gravel of undifferentiated fluvial, lacustrine or eolian origin
Grand Centre Formation	Glacial sediment; very coarse sand fraction rich in igneous and metamorphic rock fragments; poor in quartz and carbonate fragments
Vilna Member	Clayey glacial sediment (till), commonly with incorporated masses of glacially displaced sediment
Kehiwin Lake Member	Sandy glacial sediment (till), overlain by stratified sand and gravel in places
Reita Lake Member	Clayey-sand glacial sediment (till)
Hilda Lake Member	Clayey glacial sediment (till), commonly with incorporated masses of glacially displaced sediment
Sand River Formation	stratified sand and gravelly sand, minor silt and clay; undetermined glaciolacustrine or glaciofluvial origin
Marie Creek Formation	Glacial sediment (till); very coarse sand fraction rich in carbonate rock fragments
Unit 2	Sandy glacial sediment (till)
Unit 1	Clayey glacial sediment (till)
Ethel Lake Formation	Stratified silt and clay, minor sand and gravel; glaciolacustrine origin
Bonnyville Formation	Glacial sediment (till); very coarse sand fraction rich in quartz fragments and poor in igneous and carbonate fragments
Unit 2	Glacial sediment (till); very sandy in eastern 2/3 of Sand River map area, less sandy in west
Unit 1	Clayey glacial sediment (till), overlain by stratified sediment in some places
Muriel Lake Formation	Stratified sand and gravel of glaciofluvial origin
Bronson Lake Formation	Clayey glacial sediment (till) mixed with clay of undetermined origin
Empress Formation	Stratified sediment overlying bedrock and underlying lowermost glacial sediment (till)
Unit 3	Stratified sand and gravel, contains clasts derived from Canadian Shield; glaciofluvial origin
Unit 2	Stratified silt and clay; undifferentiated fluvial or lacustrine origin
Unit 1	Stratified sand and gravel, composed primarily of chert and quartzite derived from the Cordilleran Mountains; preglacial fluvial origin

Table: 2 Properties which characterize the glacial formations (tills) in the Sand River map area.



N = Number of testholes in which unit is recognized
n = Number of samples analysed from testholes
♦ Mean value of the means from all testholes
— Standard deviation

Table 3. Summary of geological events during the late Pliocene and the Quaternary in the Sand River map area.

Quaternary		
Nonglacial	Erosion & Deposition	Post Glacial Stratified Deposits
(Holocene)		
Retreat	Deposition & Erosion	Post Glacial Stratified Deposits
Cold Lake Glaciation	Deposition	Grand Centre Fm.
Lac La Biche Lobe		- Vilna Member - till
Seibert Lobe		- Kehiwin Lake Member - till
Primrose Lobe		- Reita Lake Member - till
		- Hilda Lake Member - till
Advance	Deposition	Sand River Fm. - stratified deposits
Nonglacial	Erosion and Weathering	Oxidation of Marie Creek and Bonnyville Fms.
Retreat	Deposition	Sand River Fm. - stratified deposits
Ardmore Glaciation	Deposition	Marie Creek Fm.
		- Unit 2 (till)
		- Unit 1 (till)
Advance	Deposition	Ethel Lake Fm. - stratified deposits
Nonglacial	Weathering and Erosion	Oxidation of Bonnyville Fm.
Retreat	Deposition	Ethel Lake Fm. - stratified deposits
Fort Kent Glaciation	Deposition	Bonnyville Fm.
		- Unit 2 - till
		- Unit 1 - till & stratified deposits
Advance	Deposition	Muriel Lake Fm. - stratified deposits
Nonglacial	Erosion, Weathering	Oxidation of Bronson Lake Fm.
Retreat	Deposition	Muriel Lake Fm. - stratified deposits
Cherry Grove Glaciation	Deposition	Bronson Lake Fm. - diamicton (till & clay)
Advance	Deposition	Empress Fm.
		- Unit 3 - glacial sand and gravel
		- Unit 2 - silt and clay
Tertiary		
Fluvial	Erosion and Deposition	Empress Fm.
		- Unit 1 - sand and gravel
Cretaceous		
Nonmarine	Depositional	Belly River Formation - sandstone, siltstone, mudstone
Marine	Depositional	Lea Park Fm. - claystone

Empress Formation

The oldest, and lowermost formation within the surficial stratigraphic sequence consists of fluvial clay, silt, sand, or sand and gravel which rest on the floors of the major preglacial bedrock valleys, and which underlie the first glacial (till) deposits in the area. These stratified deposits comprise the Empress Formation (Whitaker and Christiansen, 1971) which, in the Sand River area, consists of three units: a basal sand or sand and gravel unit, a middle silt and clay unit, and an upper sand and gravel unit.

Empress Formation: Unit 1 Sand and Gravel

Unit 1 deposits are characterized by a clast composition consisting mainly of quartzite, conglomerate and chert clasts, with a minor amount of local bedrock shale and sandstone (Tables 1 and 3). Granitic clasts, derived from the Canadian Shield to the northeast, are absent. The clast compostion, combined with the continuous distribution of the deposits on the floors of the valleys, as far west as the foothills of Alberta, indicate a preglacial fluvial origin, deposited by ancestral rivers draining northeast from the Rocky Mountains and the plains region of Central Alberta.

Deposits of unit 1 of the Empress Formation were not examined in this study, but were mapped primarily from the driller's litholog descriptions of the Alberta Environment testholes, as well as from electric log responses of the water-well, oil company exploration, and Alberta Environment testholes. Unit 1 is differentiated from all other sand and gravel units on the basis of its clast composition. In the absence of clast description in the lithologs, unit 1 is recognized and correlated throughout the area primarily on the basis of stratigraphic position, as determined from the signatures of the electric logs. Because of this, unit 1 is correlated with confidence only within the buried preglacial valleys where it lies extensively and continuously overtop bedrock shale or sandstone.

Transitional Preglacial - Glacial Deposits

Empress Formation: Unit 2 Silt and Clay

Sand and gravel of unit 1 of the Empress Formation is conformably overlain by discontinuous deposits of silt and clay which comprise unit 2 of the Empress Formation (Tables 1 and 3). Samples of unit 2 were not available for examination, but Alberta Environment lithologs describe the material as bedded silt and clay. The silt and clay is interpreted to have been deposited from slow-moving preglacial rivers which were blocked downstream by the southward advance of the first glacier, herein named the Cherry Grove Glacier. This ponding caused the gradients of the rivers to be reduced, enabling the finer suspended sediment to be deposited. Thus, unit 2 deposits record the transition of a preglacial drainage system into a system altered by the presence of a glacier margin.

Like most of the lower units in the Quaternary sequence in the Sand River area, unit 2 is mapped from driller's litholog desciptions and electric logs, and correlated by stratigraphic position. Unit 2 is recognized with a high degree of certainty only in segments of the buried valleys where it overlies sand and gravel of unit 1, and where it is overlain by sand and gravel of unit 3 of the Empress Formation. In this stratigraphic setting unit 2 has a much lower resistivity response compared to the log responses of the sand and gravel units.

Deposits of the First Glacial Advance - Cherry Grove Glaciation

Advance Phase Deposits

Empress Formation: Unit 3 Sand and Gravel

The earliest evidence of glaciation in the map area consists of stratified sand and gravel containing granitic clasts derived from the Canadian Shield, the presence of which indicate initial transport southward by glacial ice. These constitute unit 3 of the Empress Formation (Tables 1 and 3). Unit 3 deposits are interpreted as glaciofluvial sediments. They were deposited in spillways eroded into the bedrock surface along the southward advancing margin of the Cherry Grove Glacier and, overtop unit 2 silt and clay in the major buried valleys.

Unit 3 is described in the Alberta Environment driller's lithologs as composed of "glacial" sand and gravel, meaning that granitic clasts are present. There are no other compositional properties which differentiate unit 3 sand and gravel from younger glacial sand and gravel. Consequently, unit 3 is identified primarily by stratigraphic position, as determined from the electric logs. It can be mapped with confidence only in those areas where it overlies unit 2 silt and clay, and, where it is overlain by the Bronson Lake Formation, which represents glacial sediment deposited by the Cherry Grove Glacier.

Bronson Lake Formation: Till and Clay

The oldest glacial sediment in the Sand River area is the Bronson Lake Formation. It consists of till, and clay of undetermined origin, deposited by the Cherry Grove Glacier (Tables 1 and 3). The formation is characterized by a very clayey texture, a low resistivity, and an abundance of local bedrock in the coarse sand fraction, compared to the overlying tills. Presumably, large areas of exposed bedrock were overridden and eroded by the first glacial advance in the area. Incorporation of this exposed bedrock material likely accounts for the clayey nature of the formation. This is supported by driller's lithologs which describe the formation as being composed of "clayey till" or "clay". In some descriptions the unit is logged as "rafted shale", which suggests that displaced bedrock shale forms some of the unit. Incorporation of bedrock material is also supported by the composition of the very coarse sand fraction. The data from both Gold's study and this study show that the Bronson Lake till characteristically contains an abundance of local bedrock (14% to 50%), in the very coarse sand fraction, consisting mainly of shale and siltstone. This is significantly greater than the amount of local bedrock in the coarse sand fraction of the other tills in the area (<5%).

The clayey texture of the formation, as estimated from the electric logs, is also supported by the textural analyses from the one auger testhole in which the Bronson Lake till was recognized. In that hole, the Bronson Lake till contains about 24% sand and 44% clay (Table 2). Gold's textural analyses are also used to characterize the regional properties of the Bronson Lake till, though the results show a variable texture, ranging from very sandy (47% sand, 7% clay) to less sandy and more clayey (30% sand, 12% clay).

The Bronson Lake Formation does not outcrop in the map area, but sidewall samples from a number of testholes have been collected by Alberta Environment and analysed by C. Gold, and auger samples have been collected by the Alberta Geological Survey. These samples have been used to differentiate the formation from nonglacial deposits, such as silt and clay of the Empress Formation, but the formation has been mapped and correlated primarily on the basis of stratigraphic position, based on electric log interpretations.

Retreat Phase Deposits

Muriel Lake Formation: Clay, Sand, and Gravel

Stratified sediment, consisting mainly of sand and gravel, with lesser amounts of silt and clay, overlies the Bronson Lake Formation in segments of the buried valleys, and, on the surface of the bedrock on the uplands between the valleys. These stratified deposits constitute the Muriel Lake Formation (Tables 1 and 3). It is considered that most of these sediments, were deposited by glacial meltwater in contact with the retreating margin of the Cherry Grove Glacier, though conceiveably some of the deposits in the northeast were deposited along the advancing margin of the following Fort Kent Glacier (Table 3).

Stratified deposits of the Muriel Lake Formation do not outcrop, but are identified by drillers' litholog descriptions, descriptions of auger samples, and electric logs. Granitic clasts, indicating a glacial source, are descibed in the lithologs, but there are no lithologic properties which differentiate the Muriel Lake gravel from the glacial gravels higher or lower in the stratigraphic sequence.

The Muriel Lake Formation is mapped mainly from the lithologs and correlated by stratigraphic position, using electric log properties. The formation is most clearly defined in segments of the major buried valleys where it overlies clayey glacial sediment of the Bronson Lake Formation, and where it is overlain by till of the Bonnyville Formation. In those places where the underlying Bronson Lake Formation is absent, the Muriel Lake Formation is very difficult to differentiate from the underlying unit 3 of the Empress Formation. Stratigraphic position and elevation of the formation top are used to map the lateral continuity of the formation onto the bedrock uplands flanking the buried valleys.

Nonglacial Period

In the one auger testhole where the Bronson Lake till is recognized, the till is directly overlain by till of the Bonnyville Formation. In this testhole a well developed oxidized profile is present on the surface of the Bronson Lake Formation and this is evidence that a nonglacial weathering period followed the deposition of the Bronson Lake Formation and retreat of the Cherry Grove Glacier.

Deposits of the Second Glacial Advance - Fort Kent Glaciation

Advance Phase Deposits

Bonnyville Formation: Till, Minor Sand and Gravel

As previously discussed, it is possible that some of the stratified sediment of the Muriel Lake Formation was deposited by glacial meltwater during the advance phase of the second glaciation, the Fort Kent Glacier. The extent, or amount of deposition associated with the advance is unknown however.

The second glacial formation in the stratigraphic sequence consists of till, and lesser amounts of sand and gravel, deposited by the Fort Kent Glacier. This glacial sediment constitutes the Bonnyville Formation (Tables 1 and 3), which, in the Sand River area, is composed of two units: unit 1, a lower clayey till, locally overlain by sand and gravel, and unit 2, an upper sandy till. Neither of the units of the Bonnyville Formation outcrop in the study area. Unit 1 has been mapped mainly from electric logs, though descriptions and laboratory analyses of some auger and sidewall samples were used. Unit 2 has been mapped almost entirely from descriptions and laboratory analyses of auger samples, supplemented with electric logs in those areas where the unit is particularily thick and not penetrated by auger.

The thicknesses of unit 1 and unit 2 individually range from less than 10 m to in excess of 40 m. Unit 1 till is differentiated from unit 2 till primarily on the basis of electric log response, supplemented with matrix texture data. Unit 1 is much less sandy and more clayey (25% to 35% sand, 40% to 45% clay) than unit 2 (45% to 55% sand, 15% to 25% clay, Table 2), and this is reflected by a much lower resistivity response for unit 1. In places along segments of the Helina and Beverly Valleys thick sequences of sand and gravel (> 5 m) lie extensively between the tills of the two units. These thick, coarse stratified sediments are presumed to represent fluvial deposits, deposited in an ice-free setting rather than by basal melt-out from the glacier. Although the presence of these stratified deposits suggests a retreat and readvance of the Fort Kent Glacier, which may account for the two till units, in many places unit 2 till has a gradational contact with unit 1, which suggests the two units are textural facies of a single-event deposit.

Compared to the tills of all the other formations, both tills of the Bonnyville Formation characteristically have a greater amount of quartz (30% to 35%), a lesser amount of igneous and metamorphic rocks (50% to 60%) and a lesser amount of carbonates (5%), particularily dolostone (1% to 2%) in the very coarse sand fraction (Table 2). Futhermore, unit 2 of the Bonnyville Formation has a lower matrix carbonate content (about 10%) compared to the carbonate content of the overlying till of the Marie Creek Formation (about 17%), and a much higher ratio of calcite to dolomite (about .37) compared to either unit 2 of the Marie Creek Formation (about .17) or, all members of the Grand Centre Formation (about .24 to .33, Table 2). Locally, matrix texture can be used to characterize unit 2 as well. For example, unit 2 is the sandiest till (about 48%), and contains the most amount of very coarse sand (about 2.8%) in the east part of the map area, though it becomes much less sandy and more clayey in the west (Table 2). Also in the west, the Bonnyville Formation is characterized by a well-developed oxidized profile on its surface.

Although the combination of all of the above properties are used to characterize the Bonnyville Formation, it is the abundance of quartz in the very coarse sand fraction which proves to be the most reliable tool for regional correlations.

Retreat Phase Deposits

Ethel Lake Formation: Silt, Sand and Gravel

As will be discussed later, the bulk of the Ethel Lake Formation is composed of stratified silt and clay which was deposited during the advance of the third major glaciation in the map area. However, part of the Ethel Lake Formation consists of silt, sand and gravel which lie within a poorly developed drainage system on the surface of the Bonnyville Formation in the central part of the map area. These sediments are interpreted to have been deposited by glacial meltwater during the retreat of the Fort Kent Glacier (Tables 1 and 3).

The Ethel Lake Formation does not outcrop in the map area, but is mapped from litholog descriptions of drill cuttings, examination of auger samples, and from the electric log responses. There are no petrologic composition data which differentiate sand and gravel deposits of the Ethel Lake Formation from similar deposits of other formations, consequently, stratigraphic postion is the primary tool used for correlation.

Nonglacial Period

A poorly developed oxidized horizon on the surface of the Bonnyville Formation in the east, and a well developed oxidized horizon in the west is evidence that a prolonged weathering period followed the retreat of the Fort Kent Glacier from the map area.

Deposits of the Third Glacial Advance - Ardmore Glaciation

Advance Phase Deposits

Ethel Lake Formation: Silt and Clay

A series of ice-marginal proglacial lakes developed during the advance phase of the Ardmore Glacier, likely due to ponding of the regional northeast drainage, and meltwater issuing off the glacier surface. Silt and clay was deposited from these lakes, not only in the lowlands, but also on the flanks of the uplands as the glacial and proglacial lake margins advanced southward. These finely bedded lacustrine deposits constitute the bulk of the Ethel Lake Formation in the Sand River map area (Tables 1 and 3). In places, the fine lacustrine sediments are interbedded with coarser sand and gravel, and this is interpreted to be fluvial outwash deposited in ice-contact deltas along the glacier margin.

The Ethel Lake Formation is not known to outcrop in map area. Silt and clay of the formation have been mapped from dry auger samples which show that the deposits are generally well bedded, in places very finely bedded. Electric and lithologs are used mainly to supplement the dry auger data.

The Ethel Lake Formation is correlated throughout the map area primarily by stratigraphic position. It is the most widespread clayey stratified unit of all the stratified units in the Quaternary sequence in the Sand River Area. The formation is most easily mapped in the central and southeastern parts of the map area where the finely bedded silt and clay deposits are underlain by the sandy till of the Bonnyville Formation and, are overlain by the sandy, high carbonate till of the Marie Creek Formation. Interestingly, the fine deposits are either absent, or sporadically distributed in the lowlands in the east. This seems peculiar because it is in these lowlands where the most extensive and thickest deposits would be expected to be found.

Marie Creek Formation: Till

The third glacial formation in the stratigraphic sequence consists of till deposited by the Ardmore Glacier. This sediment comprises the Marie Creek Formation (Tables 1 and 3) which, in the Sand River area, consists of two units: unit 1, a lower clayey till, and unit 2, an upper sandy till.

Unit 1 does not outcrop in the map area, but is recognized and mapped from dry auger samples and analytical data. The top of unit 2 has been studied from exposures along stream and road cuts, but the entire unit has been mapped mainly from the analyses of dry auger samples. Resistivity logs are also used to map the top of unit 2 in areas where analytical data area absent.

The two tills of the Marie Creek Formation are not considered to represent deposits of different advances of the Ardmore Glacier, but rather are simply textural facies of a single deposit from one glacial advance. Unit 1 is much more clayey and less sandy than unit 2 (32% sand, 38% clay for unit 1, compared to 41% sand, 29% clay). Characteristically, unit 1 contains discrete "clasts" of bedded silt and clay, the source of which appears to be the erosion and incorporation of the underlying lacustrine deposits of the Ethel Lake Formation. The widespread distribution of unit 1 in the lowland in the east, combined with the paucity of the underlying Ethel Lake Formation in that lowland, is evidence that much of the Ethel Lake Formation was eroded by the overriding Ardmore Glacier. Little, if any, of the underlying silt and clay was incorporated into the upper portion of the glacier, and this probably accounts for the coarser texture of the upper till of unit 2.

The Marie Creek Formation is characterized and differentiated from tills of other formations by an abundance of carbonate rock fragments in the very coarse sand fraction (Table 2). In particular, the formation contains a greater amount of dolostone compared to limestone (ranging from 6% dolostone in unit 1 to as much as 19% at the top of unit 2). Similarily, the formation has a higher carbonate content in the silt-clay fraction, compared to the amount in any of the other till formations (ranging between 12% and 20%, Table 2). As with the coarse sand fraction, the amount of dolomite in the silt-clay fraction is much greater than calcite (calcite to dolomite ratios of about .25 in unit 1 and .17 in unit 2, Table 2).

Locally, the Marie Creek Formation can be differentiated by its texture. For example, unit 2 is much sandier than any of the tills of the overlying Grand Centre Formation, especially in the amount of very coarse sand (2.7% in unit 2, compared to 1.0% to 2.0% for the members of the Grand Centre Formation, Table 2). Unit 2 of the Marie Creek Formation is texturally similar to the underlying unit 2 of the Bonnyville Formation in the east, but the two are differentiated by the differences in the carbonate and quartz content in the very coarse sand fractions (Table 2).

In most places unit 2 of the Marie Creek Formation has a much higher resistivity response than the base of the overlying members of the Grand Centre Formation, and this is most useful for mapping unit 2 in areas where analytical data are absent. Furthermore, in outcrop, and in the subsurface, unit 2 till is much more oxidized than the Grand Centre Formation, it is more fractured and iron stained along the fractures, it is denser, and harder to drill, probably because it is sandier and drier, and, it has a higher carbonate content. All of these properties are believed to contribute to the higher resistivity values of unit 2 of the Marie Creek Formation.

In summary, it is the high carbonate content in the very coarse sand fraction of the till which characterizes and differentiates the Marie Creek Formation from all other till units in the Sand River Area.

Retreat Phase Deposits

Sand River Formation: Sand and Silt, Minor Clay and Gravel

Stratified sediment, mainly sand and silt, overlies the Marie Creek Formation in the central and eastern parts of the study area, and the Bonnyville Formation in the southwest and northwest. This sediment comprises the Sand River Formation (Tables 1 and 3). The Sand River Formation is considered to have an undifferentiated glaciolacustrine or glaciofluvial origin, deposited during both the retreat phase of the Ardmore Glacier, and during the advance phase of the last glaciation, the Cold Lake Glacier. The evidence for deposition at different times consists of an oxidized profile on the surface of some of the formation. This oxidized profile indicates that the sediment was deposited prior to, and was weathered during the nonglacial period, following the retreat of the Ardmore Glacier. Elsewhere, most of the surface of the Sand River Formation is unoxidized, which suggests that immediately after it was deposited, it was buried by till of the Grand Centre Formation.

The Sand River Formation has been mapped from both outcrop and dry-auger samples, as well as from drillers' lithologs and electric logs. The stratified deposits of the formation are generally coarser than the tills of either of the underlying Marie Creek or Bonnyville Formations, or the tills of the overlying Grand Centre Formation. Consequently, they have a higher resistivity response which enables the formation to be mapped in areas where samples are not available.

The Sand River Formation is correlated primarily by stratigraphic position. This correlation is easy in the central and eastern parts of the study, where the formation lies between the distinctive high carbonate till of the underlying Marie Creek Formation and the tills of the overlying Grand Centre Formation. However, the correlations are more difficult in the southwest and northwest corners where the Marie Creek Formation is absent, and where the Sand River Formation overlies either till of the Bonnyville Formation, or stratified deposits of the Ethel Lake Formation. However, there are no lithologic properties which differentiate silt and sand of the Sand River Formation from similar stratified deposits in the Ethel Lake Formation. Consequently, all those stratified deposits which directly overlie the Bonnyville Formation and which directly underlie the Grand Centre Formation, are considered to be as young as possible, and are mapped as the Sand River Formation.

Nonglacial Period

A prolonged nonglacial period followed the retreat of the Ardmore Glacier, during which time an extensive, highly oxidized weathered profile developed on the exposed land surface. The Marie Creek Formation formed most of the land surface and thus was extensively weathered, with the development of a strong fracture system and iron-staining. As well, that stratified sediment of the Sand River Formation which was deposited during the retreat of the Ardmore Glacier, was also oxidized. In the far southwest corner, it appears that the Marie Creek Formation was eroded immediately or shortly after it was deposited. This exposed the underlying till of the Bonnyville Formation which underwent another weathering interval. This extra weathering interval accounts for the well-developed, extensively oxidized profile on the surface of the Bonnyville Formation in the southwest, compared to the low degree of oxidation of the formation in the central and eastern parts of the area.

Deposits of the Fourth Glacial Advance - Cold Lake Glaciation

Advance Phase Deposits

Sand River Formation: Sand and Silt, Minor Clay and Gravel

As previosly discussed, the bulk of the Sand River Formation consists of sand and silt deposited from either glacial lakes or glacial meltwater, which preceeded the advance of the last major glaciation in the map area. These deposits were buried shortly thereafter by glacial sediment of the Cold Lake Glacier, and this explains why most of the Sand River Formation is not weathered or oxidized.

Grand Centre Formation: Till and Glacially Displaced Sediment

On the basis of orientations of flutes and drumlins, as well as textural differences in the glacial deposits, the Cold Lake Glacier is inferred to have had three distinct ice-lobes which deposited four members of the Grand Centre Formation (Tables 1 and 3). The first lobe, the Primrose Lobe, advanced from the northeast and deposited the Hilda Lake and Reita Lake Members. This was followed by the Seibert Lobe which advanced from the north and deposited the Kehiwin Lake Member. The final lobe, the Lac LaBiche Lobe, advanced from the northwest and deposited the Vilna Member.

All members of the Grand Centre Formation outcrop in the study area, and are mapped from natural and man-made outcrops, as well as testhole samples. Electric logs are used to map the base where the formation is particularily thick, and to define the contact with the underlying formations.

The four members of the Grand Centre Formation are differentiated by differences in stratigraphic position, geomorphology and matrix texture. The Hilda Lake and Reita Lake Members outcrop in the east part of the map area and flutes and drumlins on the surface of both members have a southwest-northeast orientation. The Hilda Lake Member underlies the Reita Lake Member for the most part, and is more clayey (27% sand and 43% clay, compared to 38% sand and 36% clay, Table 2) and darker colored. Large masses of glacially displaced sediment, including shale of the Lea Park Formation are included within the member. The Reita Lake Member forms the surface unit for most of the eastern part of the map area. It is overlapped along its western edge by the Kehiwin Lake Member, which outcrops in the central part of the map area, but is buried by the Vilna Member in the west. Flutes and drumlins on the surface of the Kehiwin Lake Member are oriented north-south. The latter member is generally the sandiest of all the members (43% sand, 25% clay, Table 2). The Vilna Member outcrops only in the west, and is stratigraphically the youngest member. Characteristically, flutes and drumlins on the surface of the Vilna Member are oriented northwest-southeast. The till is generally clayey (32% sand, 36% clay Table 2), and commonly, large masses of glacially displaced, older sediment, including bedrock, are present.

The Grand Centre Formation is characterized and differentiated from all other till formations by a number of properties. The Hilda Lake and Reita Lake Members have a greater amount of crystalline rock fragments (between 64% and 69% igneous and metamorphic) in the very coarse sand fraction compared to the amount in any of the other tills (Table 2). The Kehiwin Lake and Vilna Members have a similar amount of crystalline rocks as unit 2 of the Marie

Creek Formation, but are easily differentiated on the basis of carbonate content in the very coarse sand fraction (Table 2). The Kehiwin Lake Member and unit 2 of the Bonnyville Formation have about the same amount of crystalline rocks in the very coarse sand fraction (62% and 58% respectively), but the Bonnyville Formation has slightly more quartz (34%, compared to 29%) and less dolostone, as shown in Table 2.

With the exception of the Kehiwin Lake Member, all members of the Grand Centre Formation are generally more clayey and less sandy than the underlying unit 2 till of the the Marie Creek Formation, or unit 2 till of the Bonnyville Formation (between 27% sand and 43% clay for the Hilda Lake Member, and 38% sand and 36% clay for the Reita Lake Member, compared to about 41% sand and 29% clay for unit 2 of the Marie Creek Formation, Table 2). In fact, all members of the Grand Centre Formation can be differentiated from the underlying unit 2 of the Marie Creek Formation or unit 2 of the Bonnyville Formation by the amount of very coarse sand in the matrix. The Hilda Lake, Reita Lake and Vilna Members contain about 1.0% to 1.7% very coarse sand, whereas unit 2 of the Marie Creek Formation contains about 2.7% (Table 2). Even the Kehiwin Lake Member, which has an overall sandier texture than unit 2 of the Marie Creek Formation (43% sand, 25% clay, compared to 41% sand, 29% clay) has less coarse sand in the matrix (2.0% compared to 2.7%).

As mentioned, the Grand Centre Formation can be differentiated from unit 2 on the basis of the carbonate content, particularily the amount of dolostone, in the very coarse sand fraction (about 3% dolostone for all members of the Grand Centre Formation, compared to about 13% dolostone for the top of unit 2 of the Marie Creek Formation, Table 2). Interestingly, Table 2 shows that the limestone content of the very coarse sand fraction in the Grand Centre Formation varies little from that of the Marie Creek or Bonnyville Formations. The matrix carbonate contents of the Grand Centre and Bonnyville Formations are similar (between 8% and 11% for both units) but, the two can be differentiated on the basis of the calcite to dolomite ratios (ranging from .24 for the Hilda Lake Member to .33 for the Vilna member, compared to

.37 for the Bonnyville Formation, Table 2).

Outcrop and drilling characteristics are locally useful to differentiate the Grand Centre Formation from the underlying Marie Creek Formation. For example, the Hilda Lake, Reita Lake and Vilna Members are less oxidized and darker brown colored compared to the highly oxidized, olive brown color of the Marie Creek Formation. All members of the Grand Centre Formation are softer, moister, generally massive to slightly fissile and more easy to drill than the fractured, dry and hard till of the Marie Creek Formation. Commonly a boulder concentration separates the two formations. The more clayey, moister and softer nature of the Grand Centre Formation results in a much lower resistivity response for the formation, compared to the top of the underlying Marie Creek Formation.

Of all the above characteristics, the abundance of crystalline rock fragments in the very coarse sand fraction, stratigraphic position, and low resistivity, prove to be the most useful for differentiating and correlating the Grand Centre Formation throughout the map area.

Retreat Phase Deposits

Undifferentiated Postglacial and Recent Deposits

Undifferentiated fluvial, lacustrine, eolian and organic deposits overlie parts of the Grand Centre Formation (Fenton and Andriashek, 1983). These were deposited during both the retreat of the Cold Lake Glacier, and during recent time.

Ice-walled channels developed along the contacts of the lobes of the Cold Lake Glacier, as they retreated from the map area. In one such channel, eroded along the Seibert Lobe - Primose Lobe contact in the centre of the map area, as much as 80 m of undifferentiated fluvial and lacustrine sediment were deposited in a deeply incised valley. Presently, this meltwater channel is defined by the Sand River in the north and the Kehiwin Valley in the south (Fenton and Andriashek, 1983).

Ice-marginal meltwater also developed a channel as the Primrose Lobe retreated east and northwards. This channel meandered along the Beaver River Lowlands, depositing fluvial sand and gravelly sand near the channel, and clayey-silt along the flanks. Some of the outwash was subsequently reworked by eolian activity. The last stage in the development of this meltwater channel eroded what is now the Beaver River Valley in the east part of the map area.

IV. Empress Formation

The Empress Formation is recognized within most of the major buried valleys in the Sand River study area. The name of the unit was originally proposed as the Empress Group by Whitaker and Christiansen (1972, pg 353) to the "stratified gravel, sand, silt, and clay of fluvial, lacustrine, and colluvial origin that overlies marine Cretaceous and nonmarine Tertiary bedrock and underlies glacial till of Quaternary age in southern Saskatchewan and adjoining areas of Alberta". The name is derived from the town of Empress, Alberta and the type section for the Group is along the east bank of the South Saskatchewan River (LSD 13 Sec 9 Tp 22 Rg 29 W3M). Although Whitaker and Christiansen recognized different lithologic units within the Empress Group, they did not assign formal formation names to any of these units. While this is permissible under the rules set forth by the revised North American Stratigraphic Code (1983, article 28), in this study the "Group" status has been lowered to "Formation" status primarily for reasons of consistency in terminology. As well, until the units within the Empress Group can be clearly defined and mapped as formations, it seems more logical to treat the package as a formation first, which can then be raised to a group status if warranted.

There are no outcrops of the Empress Formation in the map area, but drill records indicate three lithologically distinct units which can be mapped within the formation: unit 1, a basal sand and gravel containing clasts derived only from the Cordillera and local bedrock, unit 2, a middle silt and clay, with minor sand and gravel beds of undetermined composition, and unit 3, an upper sand and gravel called glacial sand and gravel, with clasts derived from the Canadian Shield.

A. Unit 1: Preglacial sand and gravel

Description of Unit

Sand and gravel of unit 1 of the Empress Formation are found on the floors of the buried Helina and Beverly Valleys and, in some of their tributaries. Drill cuttings and side-wall samples indicate that the unit is composed of clasts derived from either the Cordillera, or from the local sandstone bedrock. The formation generally consists of a relatively thin basal gravel overlain by sand or gravelly sand of varied thickness. The gravel is composed primarily of light colored quartzite with some dark colored chert, and local sandstone and ironstone. In the map area the clasts average between 1 and 3 cm in size and are well rounded. Within the deposits, granitic and metamorphic clasts from the Shield are absent. The sand is characterized by a salt-and-pepper appearance which results from an abundance of light colored quartzose and dark colored chert grains. The sand is generally medium grained and the deposits are moderately well sorted and compact. Commonly the sand has an unoxidized grey color (5Y 5 / 2) except in a few places where it is oxidized a pale olive color (5Y 6 / 4).

Distribution, Extent and Thickness of Unit 1

Figure 6 shows the distribution of the sand and gravel of unit 1 within the map area. Major deposits of unit 1 are known to lie extensively within the buried Helina, Beverly and Kikino Valleys. The unit is not considered to lie on the interfluves between these valleys. Drill records from the Imperial Mills , Sinclair, and Vermilion Valleys are sparse, but do indicate that stratified sediment is present. The composition of this sediment has not been described, but it is believed to consist primarily of unit 1 sand, with little or no gravel. Southwest of the map area, segments of the buried Vegreville Valley are known to contain unit 1 sand (Carlson, 1967) but as much as 60 m of unit 3 glacial sand have also been mapped (Fenton,in prep.). It is uncertain if unit 1 lies on the floor of the St. Paul Valley.

The top of the unit ranges in elevation from as high as 550 m along the southern flank of the Beverly Valley, to as low as 455 m along the eastern segment of the Helina Valley (Figure 6).

Beverly Valley

Within the Beverly Valley unit 1 deposits are found both on the floor of the valley and within terraces along the margins. In those places where the unit is especially thick (> 15 m), it consists primarily of medium grained sand which overlies a relatively thin basal gravel (Figure 7). Other thick deposits are mapped east of Vilna (Tp 59, Rg 12), near Owlseye (Tp 59, Rg 10), and near the confluence of the Beverly and Helina Valleys in Tp 63, Rg 4 (Figure 7). The relatively higher elevations of these deposits suggests that they are terraces flanking the margins of the valley (Figure 6).

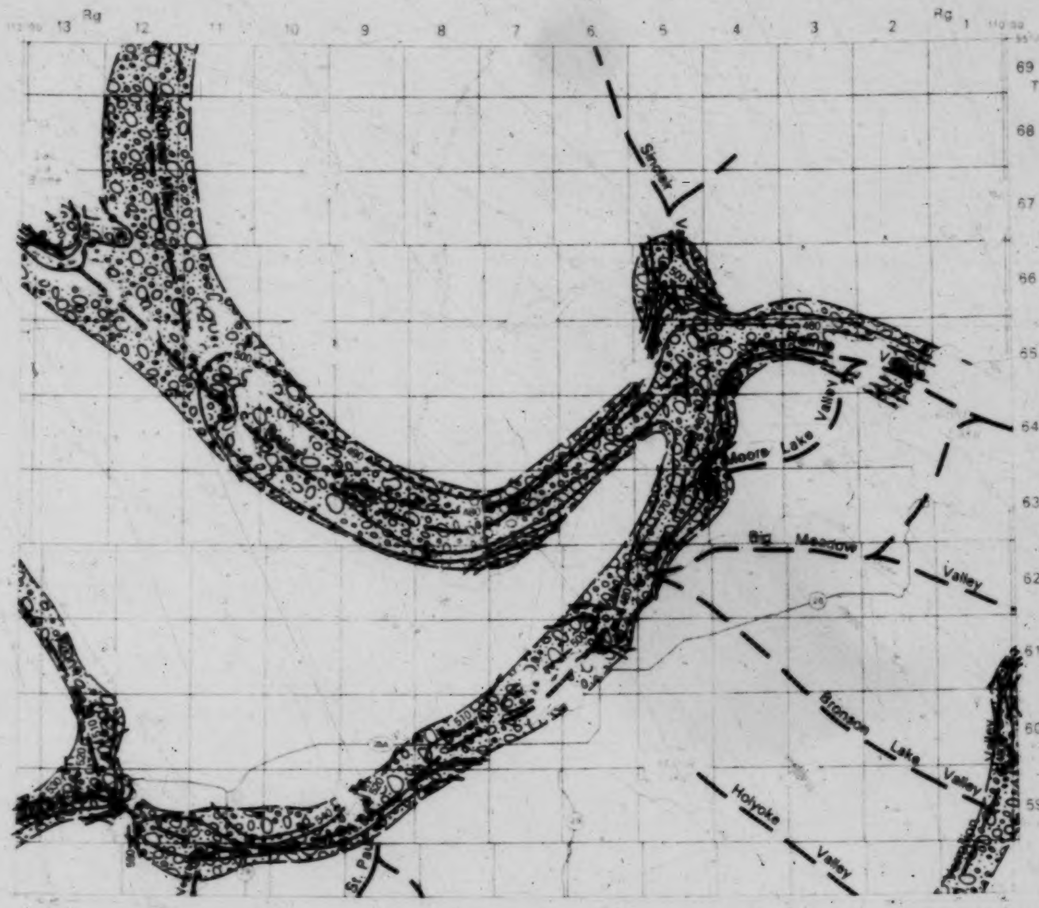

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Moore Lake Valley
Big Meadow Valley
Bronson Lake Valley
Holyoke Valley
Valley
St. Paul

Figure: 6 Elevation of the upper surface of unit 1 of the Empress Formation.

Note the confined distribution of unit 1 to the major buried preglacial valleys.

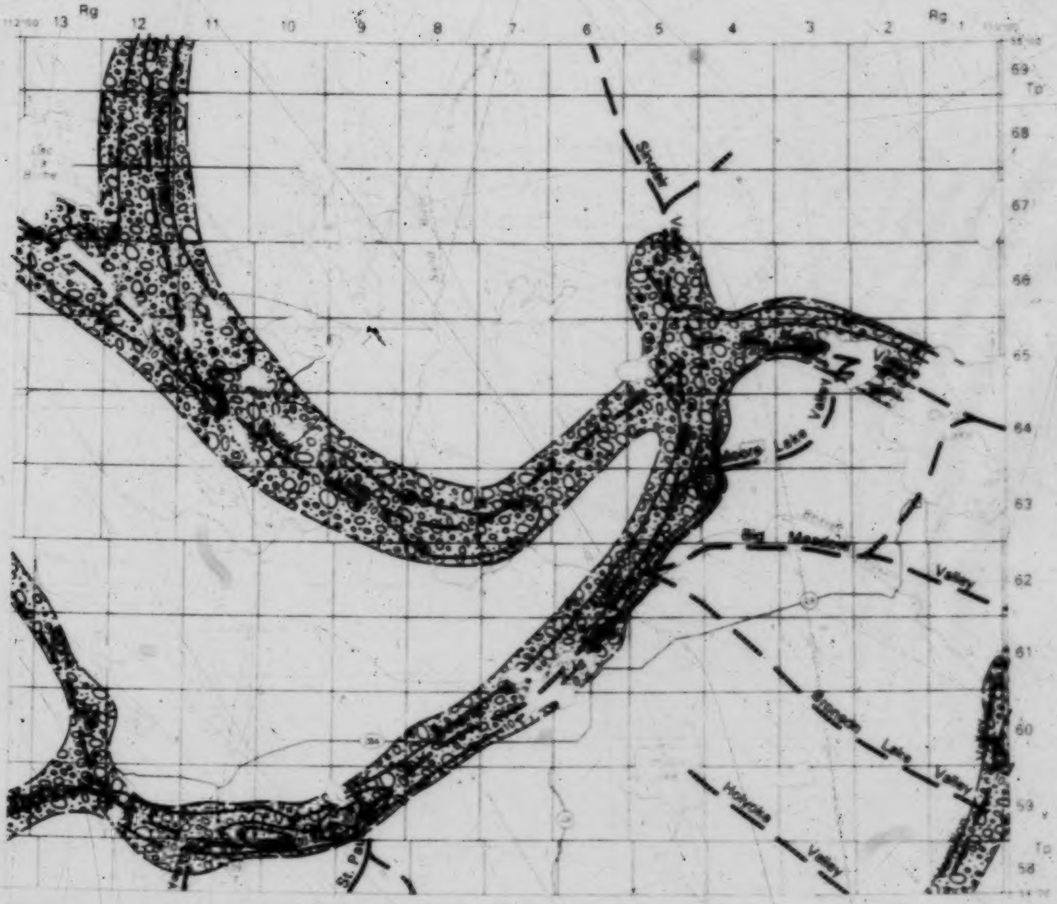
▨ Sand and Gravel

Unit Boundaries:
Approximate
Assumed

Contours, Interval 10 metres:
Defined — 500 —
Approximate — 500 —

Data Location •

Thalweg


Rg
13
12
11
10
9
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5
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2
Rg
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68
67
66
65
64
63
62
61
60
59
Tp
58
Moore Lake Valley
Big Meadow Valley
Bronson Lake Valley
Holyoke Valley
St. Paul

Figure: 7 Thickness of sand and gravel in unit 1 of the Empress Formation.
Note the isolated thick deposits along the Beverly Valley.

▨ Sand and Gravel

Unit Boundaries:
Approximate — — —
Assumed - - - - -
Isopach, Interval 10 metres ═══
Data Location ■
Thalweg ━ ━ ━

Helina Valley

Unlike the distribution within the Beverly Valley, unit 1 within the Helina Valley is confined essentially to the valley floor and is not mapped within higher terrace levels. In the northwest segment of the valley near Lac LaBiche (Tp 67, Rg 13), the elevation of unit 1 decreases to the northwest indicating that at one time drainage was in that direction (Figure 6). East of Ironwood Lake (Tp 65, Rg 11), the surface of unit 1 slopes gradually to the east (Figure 6). Within most of the Helina Valley unit 1 is generally about 10 m or less thick but east of the Beverly-Helina confluence the unit thickens to more than 20 m (Figure 7).

Kikino Valley

The top of unit 1 within the Kikino Valley slopes to the northwest, indicating that the final deposition of the unit was from drainage flowing in that direction (Figure 6). In that portion of the valley near Bonnie Lake in Tp 60, Rg 13, the lower stratigraphic sequence consists of a thin basal gravel, overlain by a thin clay unit containing coal layers which in turn is overlain by a thick (>50 m), dense sand unit. Palynological evidence indicates this sequence of clay and thick sand represents a displaced block of the Belly River Formation that probably has been glacially thrust overtop gravel of unit 1.

Differentiation from other Units

Sand and gravel of unit 1 are easily differentiated from the underlying shale of the Lea Park Formation. In the south-west corner of the study area where unit 1 overlies sandstone and shale of the Belly River Formation, the gravel can be easily differentiated from both the sandstone and shale beds. Where unit 1 is composed essentially of sand, its composition may be similar to the sandstone beds of the Belly River Formation and detailed petrologic or palynologic studies are necessary to differentiate these two formations. In those areas where unit 1 sand and gravel are overlain by unit 2 clay, the units are differentiated by the difference in texture and electric log responses. Where unit 2 is absent and where unit 1 is overlain by unit 3 sand and gravel, the two units can be differentiated only by their composition: unit 1 is composed mainly of quartzite and chert clasts; unit 3 is composed of clasts derived from northeast Alberta and the Canadian

Shield.

Nature of Contacts

Lower Contact

Unit 1 lies unconformably on the surface of the Lea Park and Belly River Formations. Where unit 1 overlies shale of the Lea Park or Belly River Formations the contact is easily recognized on the electric logs by the differences in resistivity (Figure 10, x-sec E1-E1', testhole E1720). In those places where unit 1 is composed only of sand and where it overlies sandstone of the Belly River Formation the contact may be difficult to recognize on the electric logs or from drill cuttings because of their similar texture and composition.

Upper Contact

The nature of the upper contact of unit 1 with the overlying units is variable. In some places along the major buried valleys the top of unit 1 is conformably overlain by clay of unit 2 of the Empress Formation and the contact is easily recognized on the electric logs. In those places where clay of unit 2 is absent and where sand and gravel of unit 3 of the Empress Formation directly overlies unit 1, the contact can be expected to be poorly defined. In those places where both units 2 and 3 are absent, unit 1 is commonly disconformably overlain by glacial sediment (till), and the contact is generally sharp (Figure 5, testhole E458).

Origin

Unit 1 of the Empress Formation in the major preglacial valleys consists of fluvial sediment deposited by rivers flowing from the Rocky Mountains. This is supported not only by the confined distribution of the unit to the floors of the large valleys, but also by the clast composition, which consists primarily of quartzite and chert eroded from outcrops in the Rocky Mountains. Softer rocks such as limestones, dolostones and local bedrock shale, sandstone, and siltstone are not common within unit 1, indicating that only the harder, more distantly travelled rocks form most of the gravel deposits. Another source of these indurated rocks could also be reworked Tertiary gravel which once

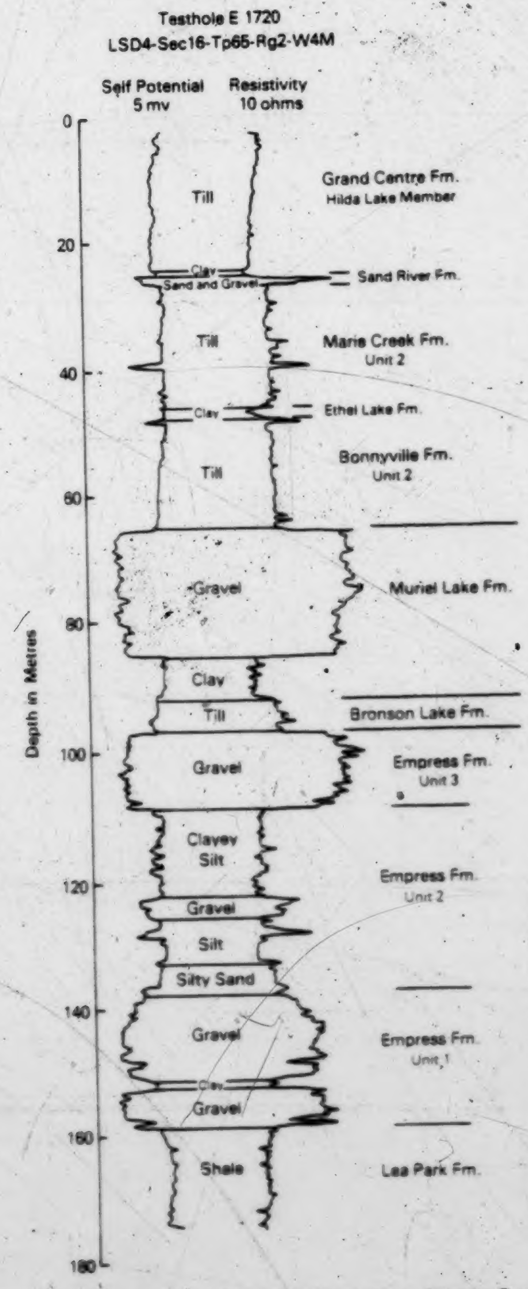

Testhole E 1720
LSD4-Sec16-Tp65-Rg2-W4M
Self Potential 5 mv
Resistivity 10 ohms
Depth in Metres
0
20
40
60
80
100
120
140
160
180
Till
Clay
Sand and Gravel
Till
Clay
Till
Gravel
Clay
Till
Gravel
Clayey Silt
Gravel
Silt
Silty Sand
Gravel
Clay
Gravel
Shale
Grand Centre Fm.
Hilda Lake Member
Sand River Fm.
Marie Creek Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
Muriel Lake Fm.
Bronson Lake Fm.
Empress Fm.
Unit 3
Empress Fm.
Unit 2
Empress Fm.
Unit 1
Lea Park Fm.

Figure: 10 Typical electric log response of the Empress Formation. Alberta Environment testhole E 1720 (LSD 1 Sec 6 Tp 65 Rg 2 W4M).

capped the uplands flanking the major river systems.

Sand deposits of unit 1 likely have more than one source. Some of the sand is likely derived from the Rocky Mountains along with the gravel. However, the bulk of the sand could be derived from the erosion of soft Cretaceous sandstone which lies within and west of the map area. Thus, the sand is probably not as far travelled as the gravel. The predominance of sand on the floors of the tributaries of the major valleys, which had their headwaters in the plains region of Alberta, certainly suggests that it was derived from the underlying bedrock.

B. Unit 2: Silt and Clay, Minor Sand and Gravel

Description of Unit

Unit 2 of the Empress Formation consists of unoxidized, dark grey silt and silty clay. Samples of the unit were not examined but litholog descriptions and electric logs indicate that the unit lies primarily within segments of the major buried valleys. Drill records describe the unit as consisting primarily of laminated silty clay or finely bedded silt and clay. In the northeast part of the study area between Tps 64 and 66, Rgs 2 and 5, (Figure 8, x-sec E1-E1'), sand and gravel are commonly interbedded with the clay. It is uncertain if all this gravel is composed of preglacial type clasts derived from the Cordilleran or, clasts which are derived from the Canadian Shield.

Distribution, Extent and Thickness

Figure 11 shows that unit 2 clay is mapped within segments of the buried Helina, Beverly, and Imperial Mills Valleys. It is believed that the unit is absent elswhere within these valleys. The unit is confined almost entirely by the valley walls, except for two small areas, one in Tp 60, Rg 9 and one in Tp 65, Rg 13, where unit 2 deposits overlie bedrock flanking the valleys (Figure 11).

The top of the unit ranges in elevation from as high as 580 m in a small deposit in the southwest portion of the Beverly Valley, to as low as 470 m in the western end of the Helina Valley (Figure 11).

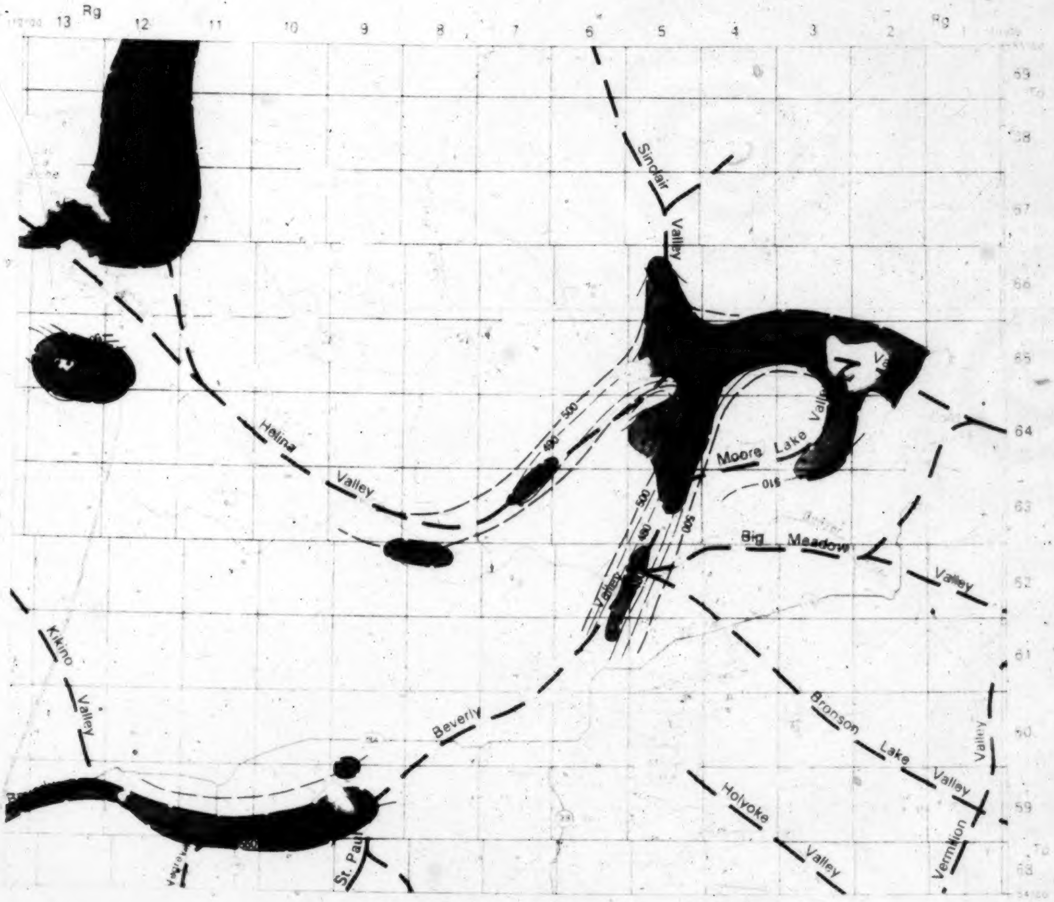

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
69
68
67
66
65
64
63
62
61
60
59
58
Sinclair Valley
Helina Valley
Moore Lake Valley
Big Meadow Valley
Kikino Valley
Beverly
Bronson Lake Valley
Holyoke Valley
Vermilion Valley
St. Paul
500
490
510
500

Figure: 11 Elevation of the upper surface of unit 2 of the Empress Formation.
Note the confined distribution of unit 2 to segments of the major preglacial valleys.

■ Silt and Clay

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - - -

Contours, Interval 10 metres:
Defined 500
Approximate 500

Data Location .... •

Thalweg .... — — —

Beverly Valley

Widespread deposits of unit 2 within the Beverly Valley are mapped in the western corner of the map area, and near the confluence with the Helina Valley (Figure 11). They are noticeably absent in the central segment of the valley.

The deposits exhibit a wide range in both thickness and elevation within these areas. For example, in Tp 59, Rg 13, unit 2 lies at an elevation of about 541 m and is only about 5 m thick. Farther east along the north flank of the valley in Tp 59, Rg 11, the unit is mapped at a considerably higher elevation of about 584 m and has a thickness of about 44 m (Figure 12).

Near the confluence of the Beverly and Helina Valleys in Tp 64, Rg 5, unit 2 is mapped both along the valley bottom and along higher terrace levels on the interfluve which divides the two valleys (Figure 11). The clay along the terraces is generally thick, locally exceeding 40 m (Figure 8, x-sec E2-E2', testhole E831, and Figure 12).

Helina Valley

Within the Helina Valley, east of the Helina-Beverly confluence in Tp 65 Rg 5, unit 2 is extensive and generally thick (Figures 11 and 12). Locally in this segment of the valley unit 2 is composed of as much as 29 m of glacial sand and gravel interbedded with silt and clay (Figure 8, x-sec E1-E1').

Unit 2 is believed to be absent throughout most of the Helina Valley but it has been mapped within the northwest part in Tp 67, Rg 13 where more than 10 m of sediment are present (Figures 11 and 12). A small deposit of unit 2 is also mapped along the the south flank of the valley in Tp 65, Rg 12-13. In this area the elevation of unit 2 decreases abruptly from south to north, and the thickness is highly varied, ranging from less than 1 m to in excess of 20 m (Figures 11 and 12).

Imperial Mills Valley

Unit 2 clay is believed to be extensive within the Imperial Mills Valley, and is mapped at much the same elevation throughout (Figure 11). The unit is generally less than 10 m thick (Figure 12).

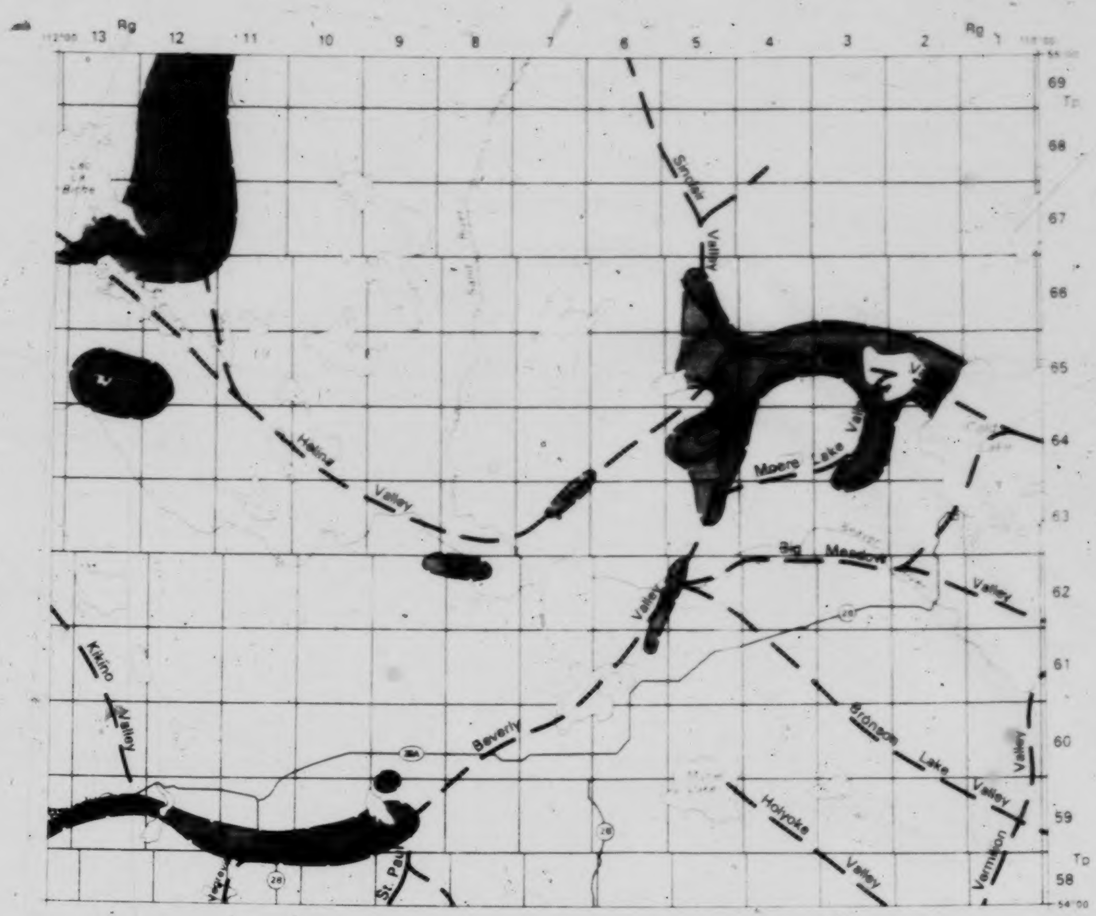

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg 1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Sinclair Valley
Helina Valley
Moore Lake Valley
Big Meadow Valley
Valley
Kikino Valley
Beverly
Bronson Lake Valley
Holyoke Valley
Vermilion Valley
St. Paul
28

Figure:12 Thickness of silt and clay in unit 2 of the Empress Formation.

Note the extensive, thick deposits near the confluence of the Helina and Beverly Valleys.

■ Silt and Clay

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - -

Isopach, Interval 10 metres 50

Data Location .... •

Thalweg .... — — —

Differentiation from other Units

In those places where clay of unit 2 overlies sand and gravel of unit 1 of the Empress Formation and, in turn is overlain by sand and gravel of unit 3, the differentiation is easily made from the lithologic and electric log properties. In those places where unit 2 lies directly on soft shale the differentiation is more difficult due to similarities in lithologies and structure (Figure 29). Unit 2 clay is differentiated from other silt and clay, such as those of the Muriel Lake, Ethel Lake and Sand River Formations, on the basis of stratigraphic position: unit 2 clay lies at or near the base of the stratigraphic sequence whereas other silt and clay deposits lie much higher and in most places are separated from unit 2 by glacial sediment.

Nature of Contacts

Lower Contact

In most places clay of unit 2 conformably overlies sand and gravel of unit 1 of the Empress Formation and this contact is generally sharp and easily recognized from the electric logs (Figure 10). Adjacent to the Moore Lake Valley, unit 2 clay overliesbedrock shale and this contact is difficult to recognize from either samples (Figure 29) or electric logs.

Upper Contact

In those segments of the Helina, Beverly and Imperial Mills Valleys, where unit 2 clay is overlain by sand and gravel of unit 3, the contact is generally sharp (Figure 8, x-sec E1-E1', testhole E765).

In a few places where unit 2 is overlain by glacial sediment, the upper contact may be poorly defined on the electric logs (Figure 8, x-sec E2-E2' testhole E457). However, this contact may be easy to define from the descriptions of drill cuttings.

Origin

Silt and clay of unit 2 are intrepreted to be either fine alluvial sediment deposited by slow moving rivers in the preglacial valleys or, lacustrine sediment deposited from lakes which formed as the drainage in the valleys was blocked by the first glacier in the area. Although the evidence is lacking, a lacustrine origin is favored for the following reasons. Firstly, the presence of fine silt and clay overtop coarser sand and gravel at the base of the valleys implies a change from a faster flowing to slower moving water. A change in the gradient is the most reasonable explanation for this. Possibly, the major rivers downcut their channels to a flat or very low gradient. However, Figure 6 shows that the top of the coarse deposits have a definite gradient to the northeast. A more likely explanation for a decrease in the gradient is that the drainage began to pond within the valleys as a result of blockage by a glacier. Large lakes then formed in the valleys.

The extensive distribution of unit 2 in the Imperial Mills Valley suggests that a large lake flooded the entire valley. The preservation of these fine deposits in this valley can be attributed to the protective mantle provided by the overlying sand and gravel of unit 3 (Figure 9, x-sec E4-E4'). Elsewhere, and particularily within the Helina and Beverly Valleys, unit 2 clay has a sporadic distribution. This can be attributed to a number of reasons. Firstly, the first glacial advance, the Cherry Grove Glacier, may have eroded the unconsolidated deposits as it advanced over the valleys. Secondly, the silt and clay of unit 2 may have been deposited contemporaneously with diamicton of that advance, and the two cannot be differentiated in the valleys. Thirdly, glacial meltwater flowing off the advancing margin may have eroded the clay. Either of the first two explanations are supported by the fact that the overlying till of the Bronson Lake Formation, is very clayey and commonly interbedded with laminated clay.

C. Unit 3: Glacial Sand and Gravel

Unit 3 of the Empress Formation consists of sand and gravel which contain abundant igneous and metamorphic clasts derived from the Canadian Shield. The unit does not outcrop in the map area but is recognized from electric logs and is described as "glacial" gravel in the driller's records, indicating that granitic clasts are present. The presence of these igneous and metamorphic clasts indicates either a glaciofluvial or interglacial fluvial origin. Hence, the term "glacial" is applied, to differentiate this gravel from unit 1 of the Empress Formation, which was deposited by preglacial drainage.

Description of Unit 3

There is a paucity of lithologic descriptions of unit 3 in the drill records. Consequently, unit 3 has been recognized and mapped primarily by stratigraphic position and electric log signature. In general, glacial sand is characterized by a typical pinkish-brown color where oxidized and by a pinkish-grey color where unoxidized. The pink tinge is due to abundant potassium feldspar grains which are derived from eroded granitic and metamorphic rocks from the Canadian Shield. The texture of the sand is described in drillers' records as ranging from fine to coarse grained and the deposits are generally soft and loose.

Glacial gravel in the map area is typically composed of rocks transported into the area by glacial meltwater or ice flowing from the northeast. These include igneous and metamorphic rocks derived from the Precambrian Shield, quartzose sandstone from Cambrian Athabasca Sandstone, carbonate rocks from the Devonian outcrops in Alberta and Saskatchewan, a minor amount of quartzite and chert which lie in the floors of the preglacial valleys, and locally derived Cretaceous sedimentary rocks. The deposits are generally coarser and less sorted than gravel of unit 1.

In some areas deposits that are interpreted to be unit 3 on the basis of stratigraphic position and geographic setting, are described as being composed of preglacial type gravel consisting of quartzite and chert. These are considered to be older preglacial sediment which have been eroded and redeposited by glacial meltwater, and technically are younger "glacial" gravel.

The electric logs indicate that locally minor amounts of silt and clay are also present within unit 3.

Distribution, Extent and Thickness

Within the Sand River map area unit 3 is mapped in three geologic settings: overlying portions of silt and clay of unit 2, at the base of a number of major buried glacial valleys and, resting on the level bedrock surface adjacent to these buried valleys.

A special case is the setting of unit 3 within the St. Paul Valley. It is believed that although the St. Paul Valley is a preglacial tributary of the Beverly Valley, the valley floor deposits are interpreted to be glacial clay, silt, sand and gravel.

The top of unit 3 ranges in elevation from as high as 600 m on the interfluve between the Beverly and St. Paul Valleys, to as low as 480 m southeast of the Moore Lake Valley.

A. Areas where unit 3 overlies unit 2

Sand and gravel of unit 3 are most easily recognized and mapped in those areas where they overlie clay of unit 2 and in turn, are overlain by glacial sediment. This stratigraphic setting is found only within segments of the Beverly, Helina, and Imperial Mills Valleys (Figures 11 and 13).

Beverly Valley

Unit 3 is extensive in the western part of the Beverly Valley, and near the Beverly-Helina confluence in Tp 65, Rg 5 (Figure 13). It may also be present in the central segment but is not shown, either because data are lacking or, because unit 2 clay is absent, making it difficult to differentiate unit 3 from the underlying unit 1.

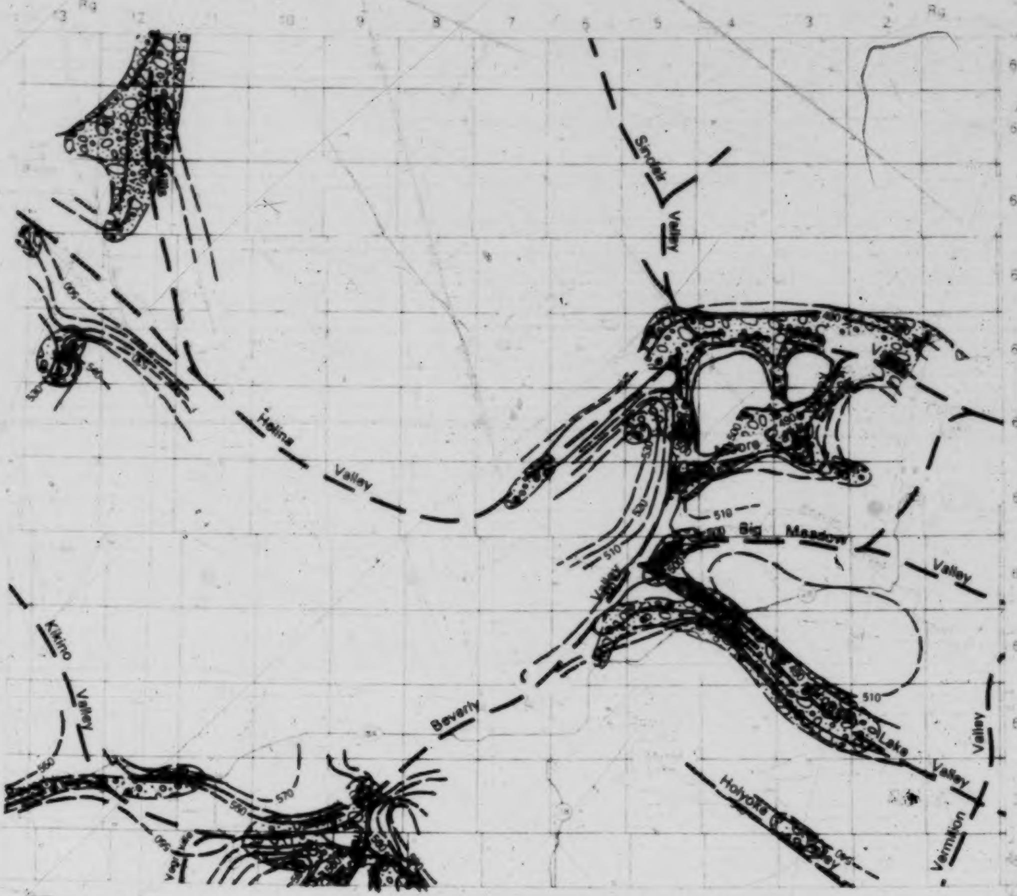
The thickness of unit 3 in the Beverly Valley is varied, ranging from a few metres to more than 40 m (Figure 14). As much as 44 m of clay and gravel are mapped in Tp 59, Rg 9, Tp 62 Rg 5, and in Tp 64, Rg 5 near the confluence with the Helina Valley (Figure 8, x-sec E2-E2′ testhole E803).

Helina Valley

Unit 3 is absent or discontinuous in the central and western part of the Helina Valley, but is extensive east of the Beverly-Helina confluence in Tp 65, Rg 5 (Figure 13). In this segment of the valley unit 3 lies at approximately the same elevation, and ranges between 12 m and 16 m in thickness (Figure 14).

Imperial Mills Valley

Unit 3 is considered to be extensive throughout most of the Imperial Mills Valley (Figure 9, x-sec E4-E4′). Figure 13 shows that the top of the unit has moderate slope from north to south. The deposits are >10 m in thickness along the western flank of the valley (Figure 14).


Rg
13
12
11
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9
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5
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3
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Rg
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Sinclair
Valley
Helina
Valley
Kikino
Valley
Beverly
Big
Meadow
Valley
Lake
Valley
Holyoke
Valley
Vermilion
Valley
510
570
560
550
540
530
500

Figure: 13 Elevation of the upper surface of unit 3 of the Empress Formation.

Note the confined distribution of unit 3 to segments of the buried preglacial and glacial valleys.

▨ Sand and Gravel

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - -

Contours, Interval 10 metres:

Defined 500

Approximate 500

Data Location .... •

Thalweg .... — — —

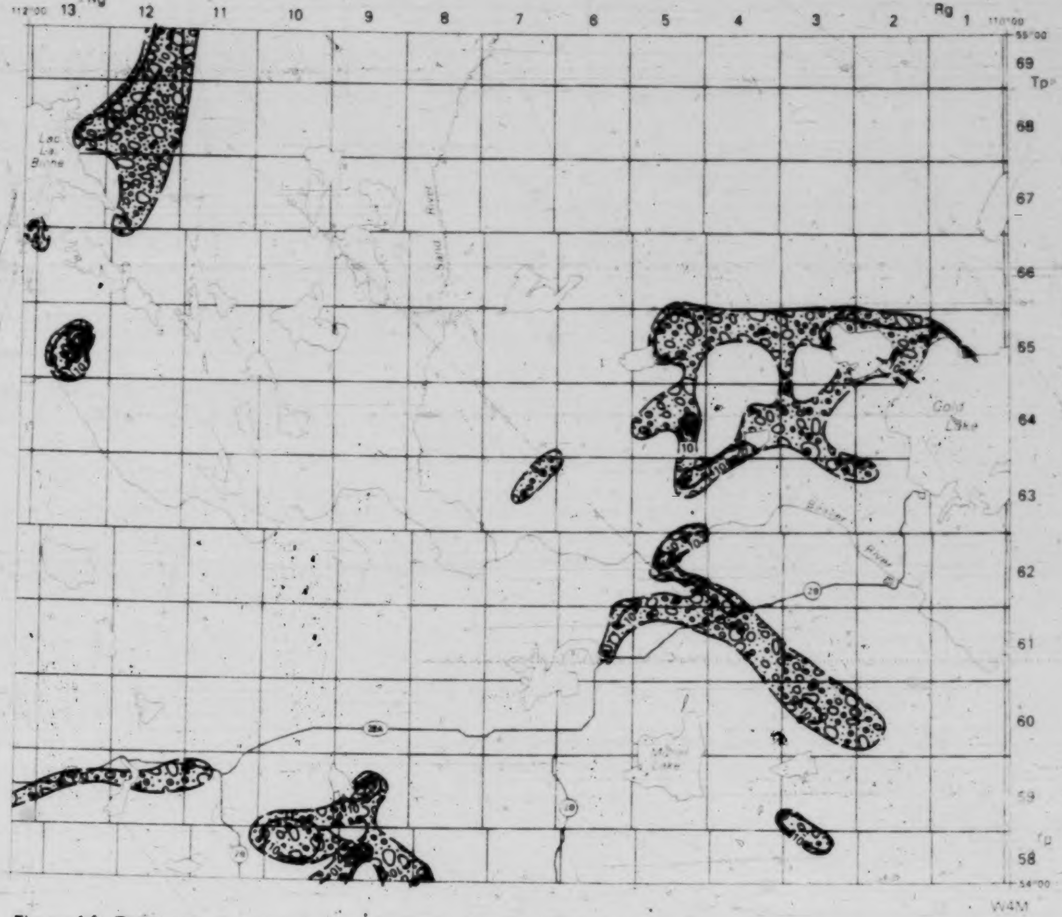

112°00
Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
58
Tp
54°00
W4M
Lac La Biche
Sand River
Gold Lake
Beaver River
10
28
28A

Figure: 14 Thickness of sand and gravel in unit 3 of the Empress Formation.

▨ Sand and Gravel

Unit Boundaries:
Approximate.................... ———
Assumed........................ – – –
Isopach, Interval 10 metres.............. —50—
Data Location........................... ●

B. Areas where unit 3 lies at the base of buried glacial valleys

Unit 3 lies at the base of segments of the buried Holyoke, Bronson Lake, Big Meadow, and Moore Lake Valleys (Figure 3). It also lies within a small, unnamed valley which cuts through the interfluve between the Helina and Moore Lake Valleys in Tps 64-65, Rgs 3-4.

Holyoke Valley

Unit 3 within the Holyoke Valley is mapped from only one testhole log in Tp 59, Rg 3, which shows a thick sequence of stratified sediment. The distribution and extent of the deposit in the valley could not be determined due to lack of data..

Bronson Lake Valley

Sand and gravel of unit 3 lie extensively within the central and western protions of the Bronson Lake Valley (Figure 13). Though the unit is not shown in the eastern segment of the valley, because data are lacking, it may be present there as well. Figure 13 shows that the top of unit 3 slopes gently westward from Tp 60, Rg 3, to where the Bronson Lake Valley joins the Beverly Valley in Tp 62, Rg 5. Drill records in the western end of the Bronson Lake Valley describe the composition of the deposits as chert and quartzite. It is believed that these represent sand and gravel of unit 1 which have been eroded from the Beverly Valley, and redeposited within the floor of the Bronson Lake Valley.

Unit 3 is thick (as much as 19 m) along the thalweg and western end of the Bronson Lake Valley (Figure 14). Along the valley margins unit 3 thins to less than 5 m in thickness.

Big Meadow Valley

Sand and gravel of unit 3 is mapped with certainty only in the western part of the Big Meadow Valley in Tp 62, Rg 5 (Figure 13). Stratified sediment does lie on the floor of the valley east of there in Tp 62, Rgs 1-4, but it is uncertain if the deposits are unit 3, or compositionally similar sand and gravel of the stratigraphically higher Muriel Lake Formation. Normally, glacial sediment of the Bronson Lake Formation separates unit 3 from the Muriel Lake Formation, but in this area the Bronson Lake Formation has been eroded, possibly by the meltwater which deposited the Muriel Lake Formation. Hence, the valley floor sediments in the central and eastern portion of the Big Meadow Valley are classified as the Muriel Lake Formation, even though unit 3 may lie at the very bottom.

Similar to the description of unit 3 in the west end of the Bronson Lake Valley, the composition of unit 3 in the west end of the Big Meadow Valley is described as quartzite and chert (Figure 5, testhole E1716). This gravel is also interpreted to be "preglacial" type sediment which was eroded from the Beverly Valley and redeposited on the floor of the Big Meadow Valley.

Unit 3 is as much as 18 m thick in the in the northeast corner of Tp 62, Rg 5, along the western segment of the Big Meadow Valley (Figure 14). The anomalously thick deposits of sand and gravel (29 m) which, in the southwest corner of Tp 62, Rg 5 are mapped as unit 3, may possibly contain deposits of the stratigraphically higher Muriel Lake or Ethel Lake Formations, neither of which can be easily differentiated from unit 3.

Moore Lake Valley

Unit 3 has a sporadic distribution within the Moore Lake Valley (Figure 13), likely due to fluvial erosion. For example, in testhole E762 situated near Ethel Lake in Tp 64, Rg 3, a thick sequence of stratigraphically younger silt and clay fills in a narrow channel which cut into and eroded all deposits down to bedrock (Figure 8, x-sec E1-E1').

Generally unit 3 is about 10 m or less thick within the Moore Lake Valley, but thick deposits are mapped within the west end of the valley in Tp 63, Rg 4 (Figure 14). Here unit 3 consists of more than 78 m of clay, sand and gravel which apparently fill a deeply eroded part of the channel (Figure 9, x-sec N2-N2', testhole E774).

C. Areas where unit 3 lies on bedrock interfluves

Unit 3 is found within a few small areas ontop of the level bedrock surface adjacent to the buried valleys. One such area lies in the interfluve between the Beverly Valley and the west branch of the St. Paul Valley in Tp. 58, Rg. 10. Here, unit 3 exhibits a wide range in both thickness and elevation, making it difficult to correlate (Figures 13 and 14).

A small area of unit 3 extends out of the Moore Lake Valley and onto the bedrock surface along its southeast flank in Tps 63-64, Rgs 2-3 (Figure 13). In this area the deposits are generally less than 10 m thick (Figure 14).

A complex sequence of silt, sand, and gravel in Tp 65, Rg 13 is interpreted to be unit 3 on the basis of stratigraphic position and elevation. The unit appears to lie in a poorly defined valley which slopes northwest towards the Helina Valley. Deposits , ranging from 5 m at the base of the valley, to as much as 47 m in the northeast corner of the deposit (Figures 13 and 14).

D. Unit 3 in the St. Paul Valley

The deposits within the St. Paul Valley are interpreted to be unit 3 on the basis of stratigraphic position: they rest on the bedrock floor, are higher in elevation than unit 1 within the Beverly Valley to the north, and can be correlated on the basis of elevation with unit 3 deposits, which overlie unit 2 clay, within the Beverly Valley to the north. Drill records show that the unit appears to be discontinuous within the valley and, that it contains significant amounts of clay as well as sand and gravel.

The top of unit 3 in the east branch of the St. Paul Valley slopes to the northwest; in the west branch the top slopes to the southwest (Figure 13). The thickness of unit 3 within both branches of the valley is varied, ranging from 3 to 24 m (Figure 14).

Differentiation from other units

Where unit 3 sand and gravel overlie shale of the Lea Park Formation, the two units are easily differentiated by differences in lithology and electric log response (Figure 5, testhole E1712). In a few places where unit 3 consits of a thick sequence of clay which lies directly on bedrock, such as in the St. Paul Valley, the differentiation from the shale is difficult.

The differentiation between unit 3, and units 1 and 2, has been previously discussed.

Where unit 3 sand and gravel are directly overlain by younger glacial sand and gravel deposits, the differentiation is difficult because of similarities in composition. Commonly, this is a problem in the eastern part of the Bronson Lake Valley in the map area, where the Muriel Lake Formation is believed to directly overlie unit 3 (Figure 8, x-sec E1-E1'). In these settings the deposits which are classified as unit 3 may in fact be composed of more than unit, superimposed on top of one another. This can account for some of the anomalously thick sequences of unit 3 shown in Figure 14.

Nature of Contacts

Lower contact

Sharp lower contacts are evident where unit 3 sand and gravel lie both unconformably on the bedrock surface within and adjacent to some of the buried glacial valleys and, conformably on unit 2 clay. This contact is easily recognized on the electric logs (Figure 10).

In those places where unit 3 might directly overlie unit 1, the contact between the two units cannot be determined without a sample examination.

Upper contact

In those places where unit 3 is overlain by glacial sediment, the upper contact is easily recognized on the electric logs (Figure 8, x-sec E2-E2', testhole E1712).

As discussed, where glacial sand and gravel of stratigraphically younger units overlie unit 3 sand and gravel, the contact between the two is difficult to determine because of similarities in composition and electric log response.

Origin

Unit 3 of the Empress Formation likely represents glaciofluvial sediment, though this origin is not certain. A glacial origin of this stratified sediment is indicated by the compostion of the sand and gravel which contain granitic clasts derived from the Canadian

Shield. These granitic clasts could only have been transported southward as glacial erratics. A fluvial origin, rather than lacustrine beach origin, is preferred mainly because most of the unit lies either on the floors of well defined channels on the bedrock surface, or, overtop older stratified deposits in segments of the major preglacial valleys.

Extensive deposits of unit 3, which overlie unit 2 along the eastern part of the Helina Valley, as well as within the Imperial Mills Valley and parts of the Beverly Valley, are interpreted as glacial outwash which preceeded the Cherry Grove Glacier as it advanced southwestward. The evidence for this, though mainly stratigraphic, is that unit 3 is buried by glacial sediment of the Cherry Grove Glacier, which means that it was deposited prior to burial by ice.

The thick deposits of unit 3 within the western end of the Moore Lake Valley, and within the Beverly Valley in Tp 59, Rgs 9-10, are interpreted to have been deposited by glacial meltwater flowing directly from an ice-margin. At the west end, the Moore Lake Valley is deep, deeper in fact than the older, more mature preglacial Beverly Valley directly to the west (Figure 9, x-sec N2-N2', testhole E774). Most likely this overdeepening resulted from high energy meltwater which presumably flowed off a steep ice-front. In this over-deepened depression as much as 78 m of sediment were deposited (Figure 14). This erosion was apparently confined to the western segment of the valley, because farther east, the elevation of the valley floor rises steeply, indicating significantly less erosion. Further evidence that the ice-margin was near the valley, is that the elevation of unit 3 in Tp 64, Rg 5 is considerably higher, and the deposits much thicker, than surrounding deposits of unit 3. This suggests that here, unit 3 was deposited in contact with ice, possibly as a kame.

A kame-like deposit is also suggested by the thick sequence of unit 3 sand and gravel which lies at a elevation higher than the surrounding deposits in the Beverly Valley in Tp 59, Rgs 9-10 (Figure 14). At this location meltwater flowed southwest off the glacier margin and deposited unit 3 sand and gravel. The water likely drained southwest along the west channel of the St. Paul Valley. This is supported by the southwest slope of the surface of unit 3 in the valley, which indicates that flow was in that direction at one time.

V. BRONSON LAKE FORMATION

Source of name: Bronson Lake, Saskatchewan, Waterhen map area, NTS 73K.

Type section: Alberta Environment rotatry testhole E802, located in LSD 5, Sec 32, Tp 61, Rg 5, W4M in the Sand River map area, NTS 73L (Figure 15).

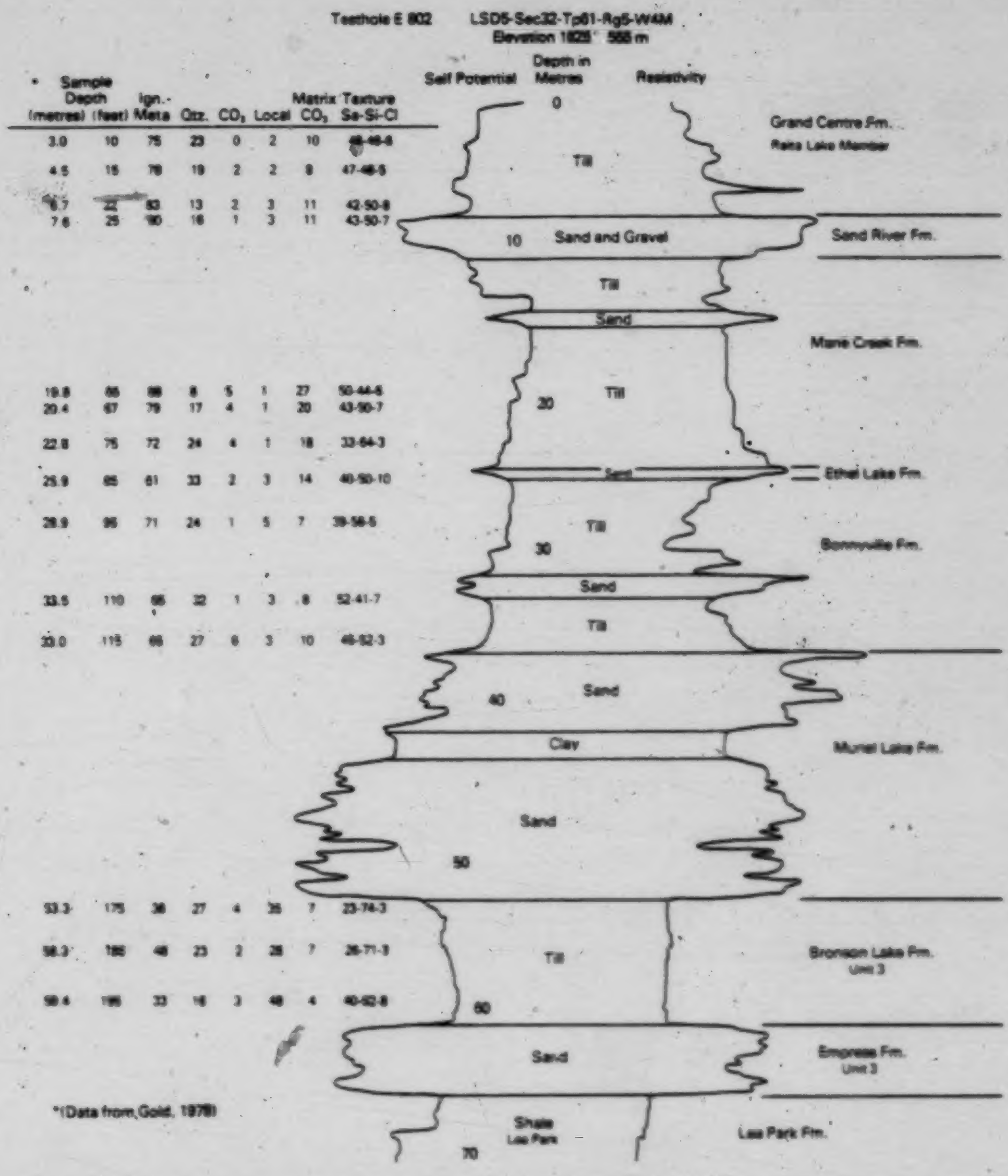
Type area: The area around Fort Kent and southeast to Angling Lake in the southeast corner of the Sand River map area, NTS 73L.

Reference sections: Alberta Environment rotary testholes E1708 (LSD 4, Sec 14, Tp 62, Rg 5, W4M) and E1712 (LSD 1, Sec 11, Tp 62, Rg 5, W4M); Alberta Geological Survey auger testhole T-32 (LSD 12, Sec 1, Tp 64, Rg 3, W4M).

A. Description of Unit

The Bronson Lake Formation does not outcrop within the map area but is recognized from auger and rotary drill cuttings, electric logs, drillers records, and stratigraphic position. The formation consists of a relatively clast-free, clayey diamicton which locally contains, or is interbedded with, well-sorted sediment, predominantly clay of undetermined origin. In most places, the formation has a very low resistivity response, presumably the result of a high clay content. The formation is very distinct on the electric logs in those places where it is both overlain and underlain by coarse stratified sediment (Figure 8, x-sec E2-E2', testholes E1708 and E1712, and Figure 15). In fact, as Figure 15 shows, the resistivity response for the unit is almost as low as that for the marine shale of the underlying Lea Park Formation.

In this study the Bronson Lake Formation was recognized in only one auger testhole (Figure 29, testhole T-32) where it is oxidized dark grey-brown (2.5Y 4 / 2). In most places however, as determined from the Alberta Environment testhole lithologs, the formation is unoxidized dark grey. In testhole T-32, the formation is composed of about 24% sand, 33% silt, and 44% clay (Table 2). The 1-2 mm sand fraction contains about 35% igneous and metamorphic rocks, 42% quartz, 3% limestone rocks, 3% dolostone rocks, and 14% local bedrock fragments, mainly shale. The silt-clay fraction contains about 9% calcareous



* Sample Depth (metres)	(feet)	Ign.-Meta	Qtz.	CO_3	Local	Matrix CO_3	Texture Sa-Si-Cl
3.0	10	75	23	0	2	10	48-46-6
4.5	15	78	19	2	2	8	47-48-5
6.7	22	83	13	2	3	11	42-50-8
7.6	25	80	16	1	3	11	43-50-7
19.8	65	86	8	5	1	27	50-44-6
20.4	67	79	17	4	1	20	43-50-7
22.8	75	72	24	4	1	18	33-64-3
25.9	85	61	33	2	3	14	40-50-10
28.9	95	71	24	1	5	7	39-56-5
33.5	110	65	32	1	3	8	52-41-7
35.0	115	66	27	6	3	10	45-52-3
53.3	175	36	27	4	35	7	23-74-3
56.3	185	48	23	2	28	7	26-71-3
59.4	195	33	16	3	48	4	40-52-8

*(Data from Gold, 1979)

Testhole E 802
LSD5-Sec32-Tp61-Rg5-W4M
Elevation 1825' 556 m
Self Potential
Depth in Metres
Resistivity
0
10
20
30
40
50
60
70
Till
Sand and Gravel
Till
Sand
Till
Sand
Till
Sand
Till
Sand
Clay
Sand
Till
Sand
Shale
Lea Park
Grand Centre Fm.
Reita Lake Member
Sand River Fm.
Marie Creek Fm.
Ethel Lake Fm.
Bonnyville Fm.
Muriel Lake Fm.
Bronson Lake Fm.
Unit 3
Empress Fm.
Unit 3
Lea Park Fm.

Figure: 15 Electric log response at the type section of the Bronson Lake Formation and Muriel Lake Formation. Alberta Environment testhole E 802 (LSD 5 Sec 32 Tp 61 Rg 5 W4M).

material with dolomite more abundant than calcite (calcite / dolomite ratio = .34, Table 2).

Gold's (1978) data shows that the diamicton has a higher aluminum content in the matrix, compared to the amount in the other diamictons. Presumably, this reflects the abundance of clay in the unit.

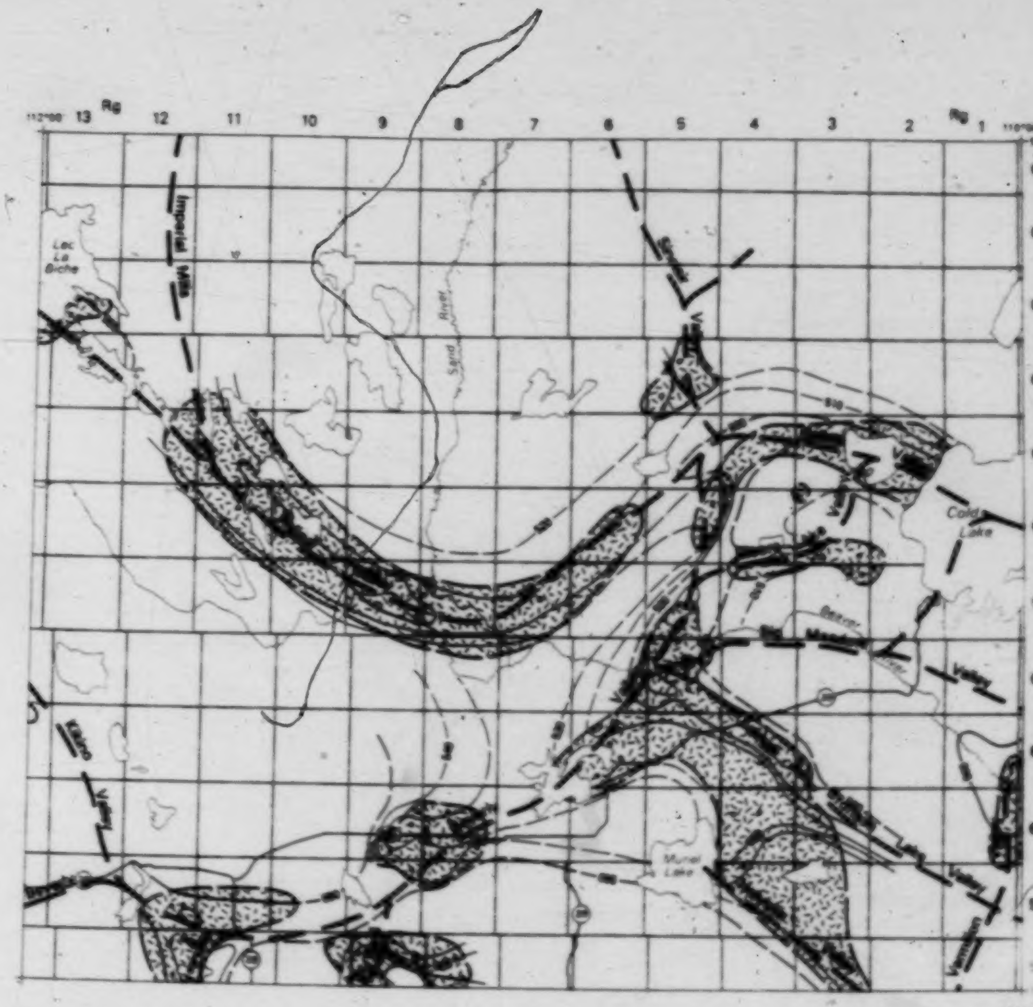
Distribution, Thickness and Subcrop Topography

The Bronson Lake Formation lies primarily within or along segments of the major buried valleys. It has not been identified in the interfluves between the valleys, except for those areas between the Bronson Lake and Holyoke Valleys in the southeast and, between the Beverly and St. Paul Valleys in the southwest (Figure 16). Within the map area the top of the formation ranges in elevation from as high as 550 m along the southwest part of the Beverly Valley, to as low as 490 m in the Beverly and Bronson Lake valleys (Figure 16).

Beverly Valley and Tributaries

The Bronson Lake Formation is discontinuous in the Beverly Valley (Figure 16). In the southwest part the distribution and extent of the formation is uncertain, primarily because only electric log data are available. A number of oil company electric logs in Tps 58-59, Rg 12, show that a clayey unit overlies the Empress Formation, and, on the basis of stratigraphic position, this unit is interpreted to be the Bronson Lake Formation. However, the clayey unit 1 of the overlying Bonnyville Formation is also present in the area, and could be miscorrelated with the Bronson Lake Formation. Similarily, the distribution of the Bronson Lake Formation directly east in the St. Paul Valley is not certain. Water-well driller's logs indicate that the formation likely lies both within the valley and on the interfluve between the St. Paul and Beverly Valleys. Generally the formation is thin in the this area, but locally it is as much as 18 m thick (Figure 17).

Two relatively extensive deposits of the Bronson Lake Formation, one in Tps 59-60, Rgs 8-9 and the other in Tps 61-63, Rgs 5-7 are mapped in the central part of the Beverly Valley (Figure 16). In both deposits the formation is thickest along the centre of the valley, but thins toward the edges (Figure 17).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Rg
1
110°00'
Tp
68
67
66
65
64
63
62
61
60
59
58
Tp
Lac La Biche
Imperial Mills
Sand River
Cold Lake
Beaver River
Valley
Muriel Lake
Vermilion
W4M

Figure: 16 Elevation of the upper surface of the Bronson Lake Formation.
Note the confined distribution of the formation to segments above the buried valleys.

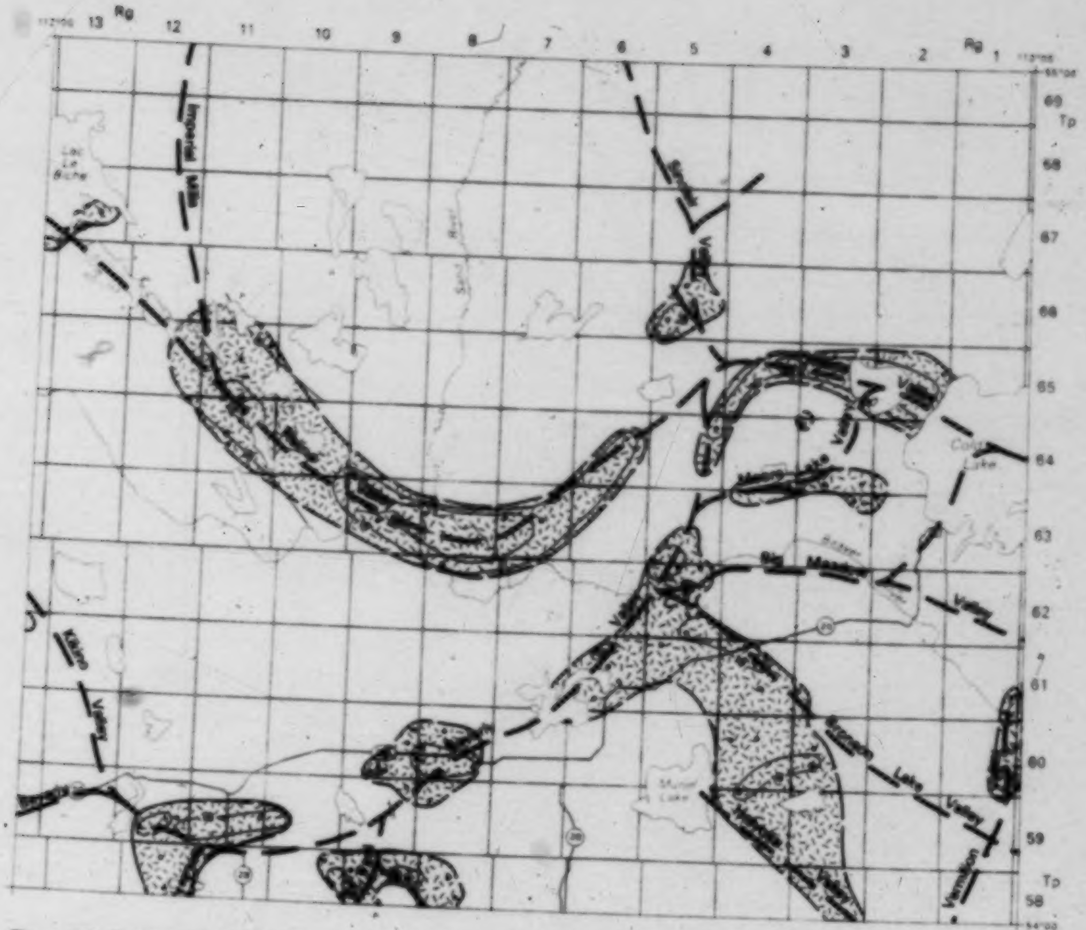
▨ Diamicton and Clay

Unit Boundaries:
Approximate
Assumed

Contours, Interval 10 metres:
Defined
Approximate

Data Location

Thalweg


Rg
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63
62
61
60
59
58
Lac La Biche
Imperial Mills
Sand River
Cold Lake
Big Meadow
Valley
Bronson Lake Valley
Kehiwin Valley
Vermilion
W4M

Figure: 17 Thickness of diamicton and clay in the Bronson-Lake Formation.
Note the extensive thick deposits along the buried Helina Valley.

▨ Diamicton and Clay

Unit Boundaries:
Approximate........ — — —
Assumed........ - - - - -
Isopach, Interval 10 metres........ ═
Data Location........ •
Thalweg........ — — —

Helina Valley and Tributaries

The Bronson Lake Formation lies within much of the Helina valley in the map area. It is uncertain if the formation extends throughout the entire valley, but it is continuous or nearly continuous in that part of the valley which extends from Tp 64, Rg 6 in the east, to Tp 65, Rg 11 in the west (Figure 16). Lithologs from a number of testholes in this area describe the formation as consisting of either "clay" or "till", indicating that the properties of the formation in this segment of the valley are varied. In addition, the sparseness of clasts combined with the high silt and clay content of the diamicton, may explain why the origin of the sediment is interpreted differently at those sites. The thickest deposits of the Bronson Lake Formation are found within this central segment of the Helina valley; as much as 28 m have been mapped in Tp 63, Rg 8 (Figure 17).

The Bronson Lake Formation is considered to be continuous within that segment of the Helina Valley west of Cold Lake in Tp 65, Rg 2. Here, it consists of both clay and diamicton which cannot be easily differentiated (testhole E831, Figure 8, x-sec E2-E2').

The Bronson Lake Formation has been mapped in the south end of the Sinclair valley where it meets the Helina valley in Tp 66, Rg 5. It is uncertain how far north or south the formation extends from there.

Oil company electric logs from testholes located above the Vermilion Valley indicate that stratified deposits of the Empress Formation are overlain by a clay unit which, on the basis of elevation and stratigraphic position, correlates with the Bronson Lake Formation in the Bronson Lake Valley to the west (Figure 9, x-sec N1-N1'). Within the Vermilion Valley, the formation ranges in thickness between 4 m and 22 m (Figure 17).

Bronson Lake, Holyoke and Moore Lake Valleys

An extensive deposit of the Bronson Lake Formation lies within the western part of the Bronson Lake Valley between Tp 61, Rg 3 and Tp 62, Rg 5 and, on the relatively flat-lying bedrock interfluve between the Holyoke Valley to the south. It is believed that the formation has been eroded along the central and eastern segments of the Bronson Lake Valley, although the data are sparse in this area. The formation is generally thick (>10 m) within the Bronson Lake valley, and especially so near the junction with the Beverly Valley in the southwest corner of Tp 62, Rg 5 (Figure 17). The formation is generally thin on the interfluve except for a 16 m thick deposit in Tp 60, Rgs 3-4.

Although there is a scarcity of data in the southeast corner of the map area, the Bronson Lake Formation is believed to extend southeast into the Holyoke Valley (Figure 16). In one testhole, the formation is less than 10 m thick.

The Bronson Lake Formation lies within the western segment of the Moore Lake Valley, and on the bedrock upland flanking the east side of the valley in Tps 63-64, Rgs 2-3 (Figure 16). A scarcity of data from the northeastern segment of the valley precludes its recognition there.

Differentiation from other Units

The Bronson Lake Formation is most easily mapped where it both overlies coarse deposits of the Empress Formation, and where it is overlain by coarse deposits of the Muriel Lake Formation. (testholes E1708 and E1712, Figure 8,x-sec E2-E2').

The Bronson Lake Formation is difficult to differentiate from clay of unit 2 of the Empress Formation because in many areas the diamicton of the formation is either interbedded with silt and clay, or contains discrete masses of clay. For example, in testhole E1771 (Figure 5) the basal part of the Bronson Lake Formation is composed of both diamicton and bedded clay, the latter of which appears differently on the electric logs. In testhole E831 (Figure 8, x-sec E2-E2') on the other hand, the diamicton and underlying clay appear similar on the electric logs, and are differentiated only by the driller's descriptions. Differentiation between unit 2 of the Empress Formation and the Bronson Lake Formation is particularily difficult in the area west of Cold Lake and Marie Lake (Tp 65, Rg 2) where clay lies both above and below diamicton of the Bronson Lake Formation (Figure 8, x-sec E1-E1').

In the eastern two-thirds of the map area, the Bronson Lake Formation can be easily differentiated from the sandy diamicton of unit 2 of the Bonnyville Formation on the basis of texture and very coarse sand composition. The Bronson Lake Formation is more clayey, and contains more locally derived bedrock and carbonate rock fragments in the very coarse sand fraction. The differentiation of the Bronson Lake Formation from unit 1 of the Bonnyville Formation is more difficult because both are clayey. In the east the two units are commonly separated by coarse stratified deposits of the Muriel Lake Formation, and this facilitates a differentiation. In the west however, the differentiation is more difficult because the Muriel Lake Formation is absent, and because both units 1 and 2 of the Bonnyville Formation are also clayey. Here, the differentiation is made on the basis of stratigraphic position as well as the relative abundance of local bedrock fragments in the very coarse sand fraction of the Bronson Lake Formation. As well, the data show that the Bronson Lake Formation has a higher aluminum content than the other diamicton units (Gold, 1978, till unit 4). More than likely this reflects the abundance of clay in the matrix.

Nature of Contacts

Lower Contact

In most places the Bronson Lake Formation overlies stratified deposits of the underlying Empress Formation. Where the Bronson Lake Formation overlies sand and gravel of the Empress Formation (units 1 and 3) the lower contact is sharp. For example, in testhole E1723, situated within the Helina valley in the central part of the map area, the Bronson Lake Formation has a sharp, disconformable contact with the top of unit 1 (Figure 9, x-sec N2-N2'). Similarily, where the Bronson Lake Formation overlies unit 3 of the Empress Formation, the lower contact is also very sharp, though maybe conformable (Figure 8, x-sec E2-E2', testholes E1708 and E1712).

Gradational contacts with the the Empress Formation are suggested in testhole E807 (Figure 8, x-sec E3-E3') where the underlying sand and gravel has been incorporated into the base of the Bronson Lake Formation.

It is believed that the Bronson Lake Formation directly overlies clay of unit 2 of the Empress Formation in only a few areas. One example is testhole T-32 (Figure 29), where oxidized diamicton of the Bronson Lake Formation overlies oxidized silt and clay of unit 2 of the Empress Formation. In fact, within the northeastern part of the map area it is difficult establish the contact between the two units because both contain considerable amounts of clay. For example, in testhole E831 (Figure 8, x-sec E2-E2'), drillers' records describe "till", which is interpreted to be the Bronson Lake

Formation, even though the electric logs show no difference between the till and the underlying clay of unit 2.

The Bronson Lake Formation overlies shale of the Lea Park Formation in a few places within the uplands flanking the buried valleys. This contact is disconformable and generally sharp, even though both formations contain an abundance of clay (Figure 9, x-sec N1-N1', testholes E801, E716, and E719). In some places however, gradational contacts are evident. For example, in testhole E799 (Figure 9, x-sec N1-N1') diamicton of the Bronson Lake Formation becomes progressively more clayey near the bedrock surface. As well, a number of drillers' records describe blocks of "ice-rafted" shale within the diamicton of the Bronson Lake Formation which suggests that in places a significant amount of the underlying bedrock has been eroded and incorporated into the formation.

Upper Contact

The upper contact of diamicton of the Bronson Lake Formation with stratified deposits of the Muriel Lake Formation is considered to be conformable and in most places, is distinct and well defined on the electric logs. This applies particularily in those areas where the Muriel Lake Formation is composed of coarse sediment (Figure 15 testhole E802). In those places where the Muriel Lake Formation consists of silt and clay, the contact with the Bronson Lake Formation is not as sharp (Figure 10, testhole E1720).

Origin

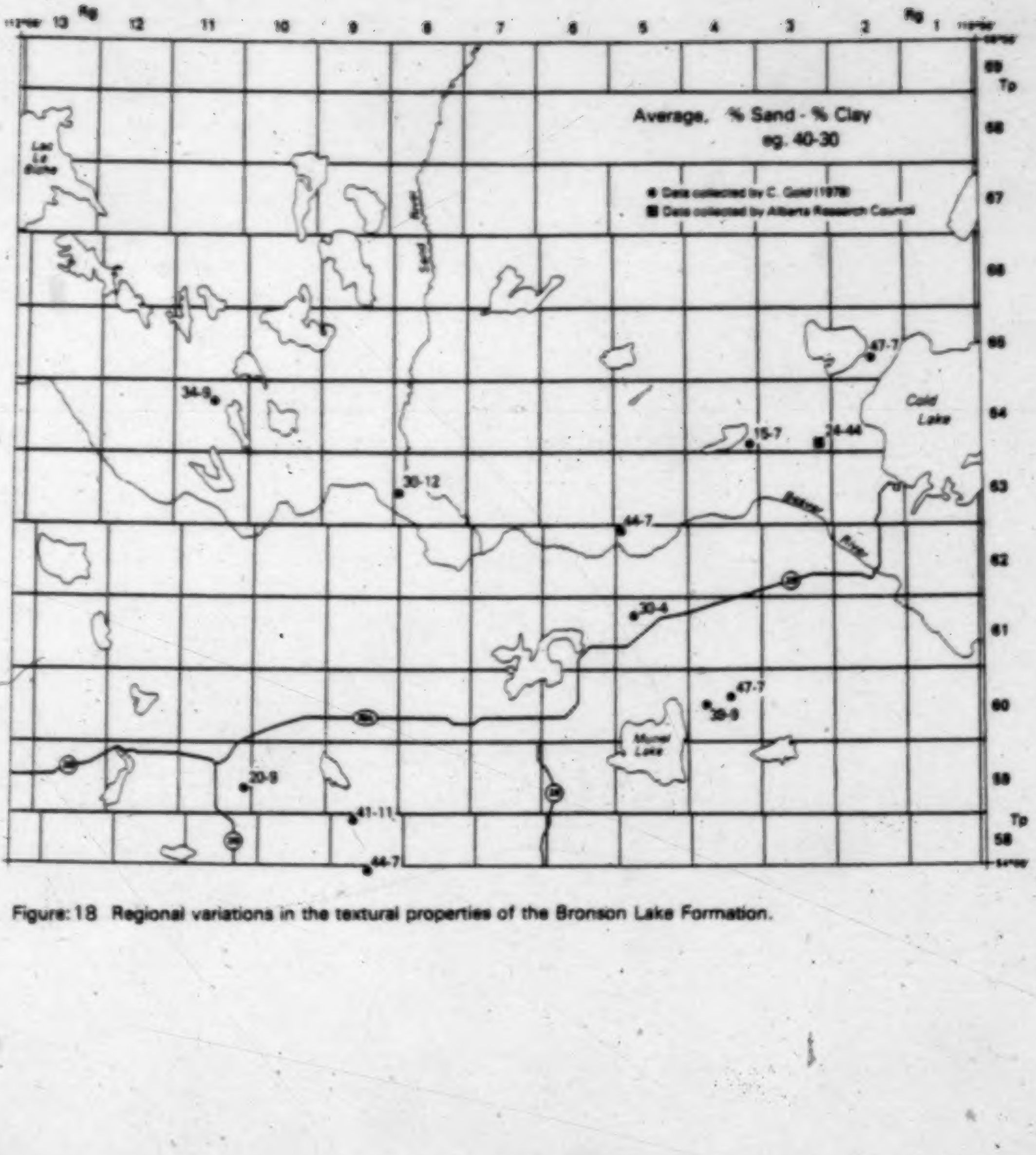
The Bronson Lake Formation represents glacial sediment deposited by the Cherry Grove Glaciation. Much of the formation is composed of diamicton that is interpreted to be glacial sediment, primarily till. However, because the formation is found at or near the base of the major buried valleys, some of this diamicton may also include slumped sediment from the valley walls.

Local variations in the texture of the Bronson Lake Formation are evident. Gold's (1978) data show that although the diamicton is generally very silty to clayey, in places it can be sandy as well. One possiblity is that glacial erosion and incorporation of the underlying sand and gravel of the Empress Formation accounts for this sandy texture

(Figure 18, testholes E765, E458, E801 and E719). Another possibility is that the sandy texture reflects a basal melt-out facies in which lenses of sand were deposited synchronously with the diamicton at the base of the glacier (Shaw 1982). There are no data to support either of these hypotheses.

Within the buried valleys and especially the Helina Valley, the diamicton of the Bronson Lake Formation is not only very clayey, but also contains discrete masses or beds of silt and clay. The source of this silt and clay is uncertain. Gold's (1978) very coarse sand composition data shows that in places the diamicton contains abundant local bedrock fragments consisting mainly of shale (Gold, 1978). This agrees with the data from testhole T-32 which also shows a relative abundance of shale clasts (as much as 14%) in the very coarse sand fraction. This high shale content of the Bronson Lake Formation, compared to the amount in other formations, suggests that significant amounts of the underlying shale of the Lea Park Formation were eroded and incorporated into the Bronson Lake Formation. Other evidence for bedrock incorporation is recorded in the drillers' lithologs along the Helina valley in the northeast corner of the map area. These logs describe clay deposits, composed of "ice-rafted" shale, which overlie "till", here defined as the Bronson Lake Formation. Christiansen (1968) also noted an abundance of matrix clay and shale fragments in the clast fraction of the lowermost till in a number of map areas of Saskatchewan. He too attributed this enrichment of clay to the erosion and incorporation vast areas of exposed bedrock by the first glacier in that area.

Although incorporation of shale likely accounts for some of the large clay masses and clayey texture of the Bronson Lake Formation, at a number of locations fluvial or lacustrine silt and clay has either been deposited penecontemporaneously with the diamicton, or, glacially eroded and incorporated into the matrix as discrete "clasts". The source of the incorporated silt and clay may be the underlying unit 2 of the Empress Formation which is considered to have been deposited in a proglacial environment as the Cherry Grove Glacier advanced into the map area. Possibly in segments of the buried valleys the Cherry Grove Glacier completely eroded unit 2 clay, and this accounts for the absence of unit 2 in parts of those valleys. Equally possible, lacustrine sediment of unit 2 of the Empress Formation, and glacial sediment of the Bronson Lake Formation were deposited contemporaneously as the Cherry Grove Glacier advanced into the map area.


Rg
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Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Average, % Sand - % Clay
eg. 40-30
● Data collected by C. Gold (1978)
■ Data collected by Alberta Research Council
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
47-7
34-9
15-7
24-44
30-12
44-7
30-4
47-7
39-9
20-9
41-11
44-7

Figure: 18 Regional variations in the textural properties of the Bronson Lake Formation.

The absence of the Bronson Lake Formation in the eastern part of the Bronson Lake Valley and within most of the Big Meadow Valley is attributed to fluvial erosion which likely occurred during the retreat of the Cherry Grove Glacier. Glacial meltwater, released during the retreat, not only eroded the Bronson Lake till from within the valley, but also deposited thick sand and gravel overtop of glacial sand and gravel of unit 3 of the Empress Formation. This produced a thicker than normal sequence of sand and gravel, likely composed of both the Muriel Lake Formation and unit 3 of the Empress Formation, at the bottom of these two valleys (see following chapter).

VI. MURIEL LAKE FORMATION

Source of name: Muriel Lake Alberta, located in the south-central part of the Sand River map area NTS 73 L.

Type Section: Alberta Environment testhole E802, located in LSD 5, Sec 32, Tp 61, Rg 5, W4M in the Sand River map area (Figure 15).

Type Area: The area north of Muriel Lake around the village of Fort Kent in the Sand River map area NTS 73L.

Reference Sections: Alberta Environment testholes E804 (LSD 4, Sec 1, Tp 64, Rg 4, W4M), E1710 (LSD 16, Sec 9, Tp 62, Rg 5, W4M), E1712 (LSD 1, Sec 11, Tp 62, Rg 5, W4M), E1708 (LSD 4, Sec 14, Tp 62, Rg 5, W4M).

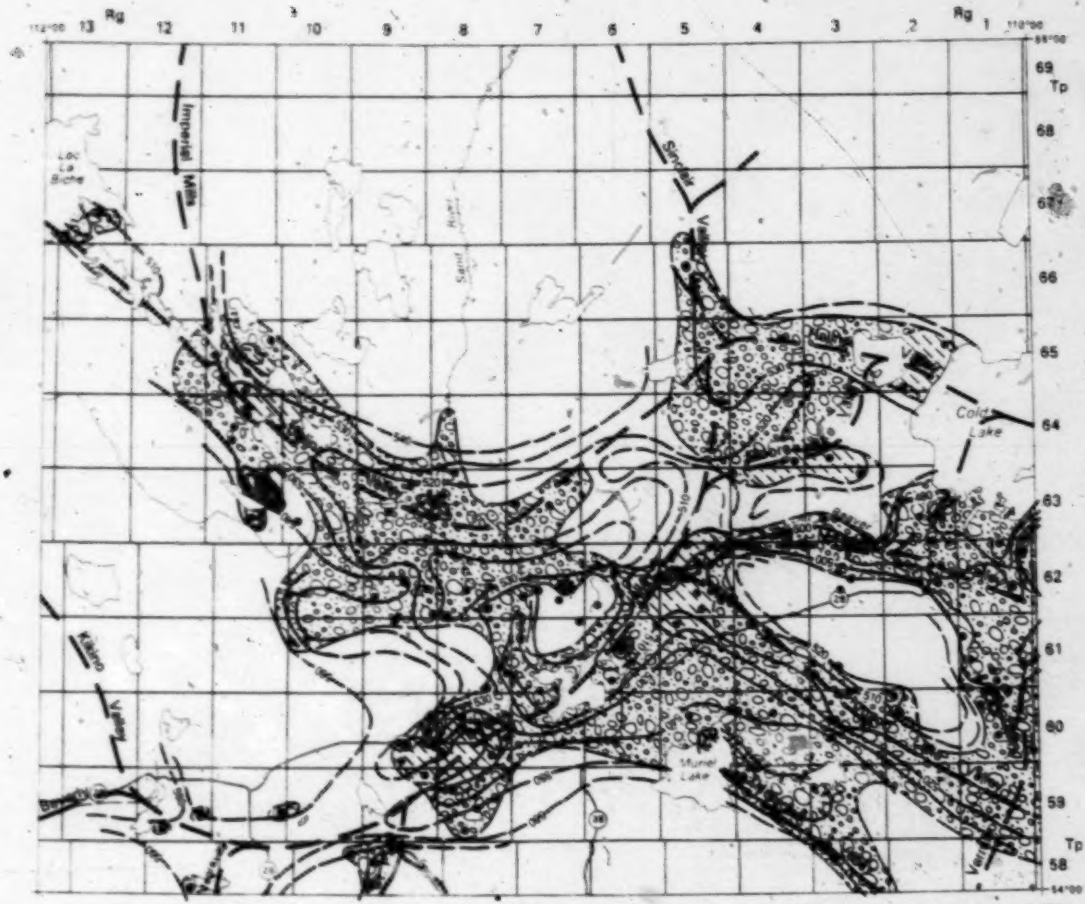
A. Description of Unit

The Muriel Lake Formation does not outcrop within the map area but is described from dry auger samples and drillers' records, and is recognized in the subsurface from geophysical logs. The formation generally consists of stratified sand, and sand and gravel with minor silt and clay beds. In some areas the formation contains significant amounts of clay interbedded with the sand and gravel, such as within the segment of the Helina Valley which lies west of Cold Lake (Figure 8, x-sec E1-E1', testhole E767). Locally, the entire formation is composed of silt and clay (Figure 5, testhole E833).

Driller's records describe small to medium sized granitic and carbonate clasts in the gravel, indicating a glaciofluvial or glaciolacustrine origin. Cobbles or boulders are uncommon. The sand is generally medium grained and well sorted, although in some testholes coarse sand was mapped. The deposits of the Muriel Lake Formation are described as unoxidized and have a light to medium gray color.

Distribution, Thickness, and Subcrop Topography

The distribution and extent of the Muriel Lake Formation is shown in Figure 19. The formation lies both within segments of the buried valleys, overtop either the Bronson Lake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Tp
58
54°00
W4M
Imperial Mills
Lac La Biche
Sand River
Cold Lake
Muriel Lake
Kikino Valley
510
500

Figure: 19 Elevation of the upper surface of the Muriel Lake Formation.

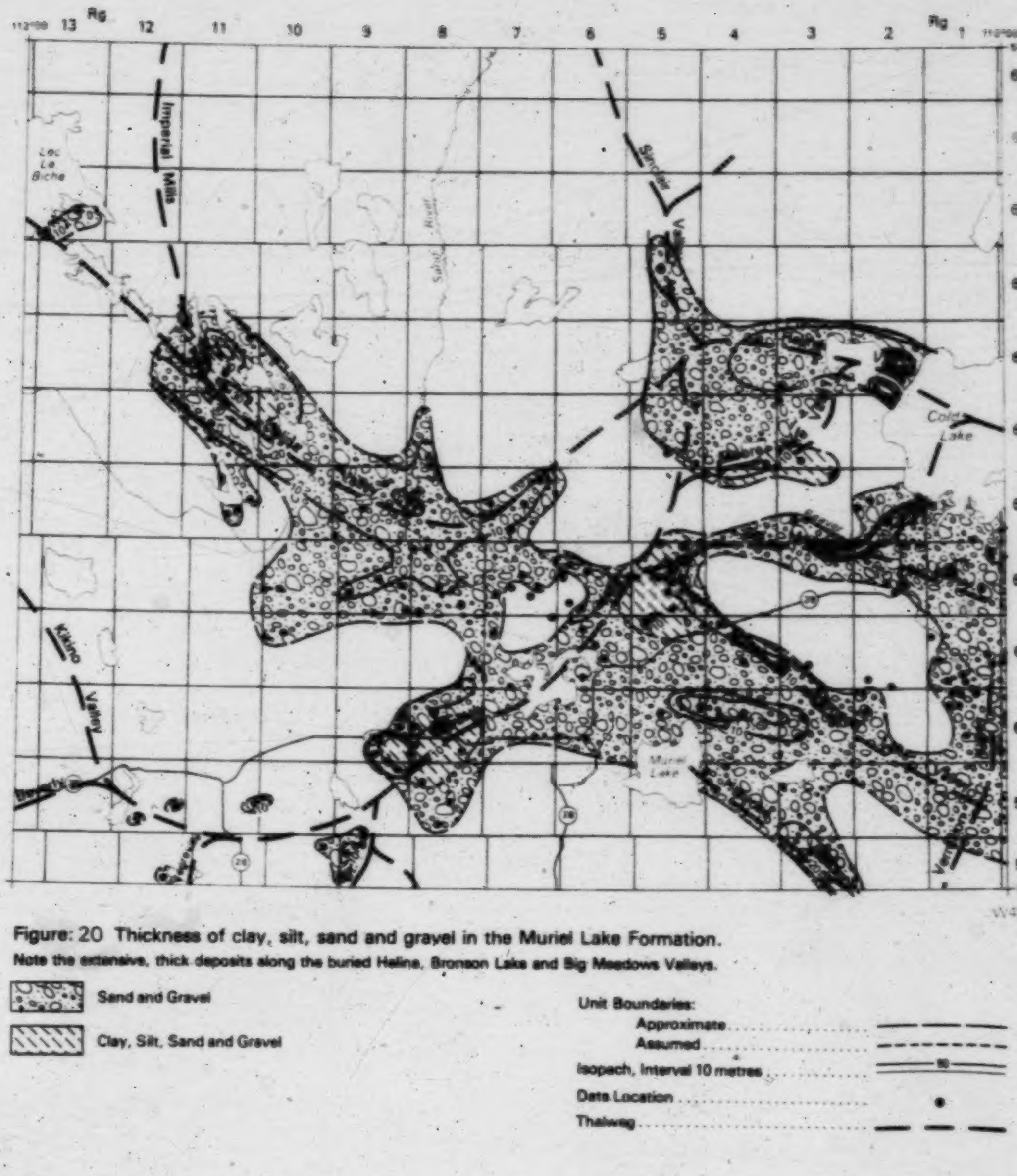
Note the widespread distribution of the formation on the bedrock interfluves in the central part of the map area.

Sand and Gravel
Clay, Silt, Sand and Gravel
Unit Boundaries:
Approximate
Assumed
Contours, Interval 10 metres:
Defined
Approximate
500
Data Location
Thalweg

Formation or the Empress Formation or, on the bedrock interfluves between the valleys. It has not been recognized in the highlands which lie north and south of the central part of the map area. The top of the formation ranges in elevation from as high as 580 m on the interfluve between the Beverly and St. Paul Valleys in the southwest, to as low as 490 m in the Beverly Valley in Tp 62, Rg 5 (Figure 19).

The distribution of the Muriel Lake Formation can be defined by two trends which intersect near Moose Lake in Tp 61, Rg 7 (Figure 19). The first trend originates within the Beverly Valley in the southwest corner of the map area and extends northeast, following the Helina Valley towards Cold Lake. In the southwest end of this trend (Tps 58-59, Rgs 9-12) the formation is mapped with small degree of certainty in a few isolated locations, primarily within segments of the Beverly and Vegreville Valleys (Figure 19). The uncertainty of the extent of the formation in this area is due to the difficulty in differentiating the Muriel Lake Formation from the Empress Formation. Farther east, in Tps 59-60, Rg 9, the formation is mapped extensively within the Beverly Valley and consists of as much as 25 m of clay, sand, and gravel (Figure 20). The formation thins eastward to about 3 m thick in Tp 62 Rg 5. The gap in the distribution of the formation in Tps 63-64, Rgs 5-6, shown in figure 19, reflects the absence of data in that area. Near the confluence of the Helina and Beverly Valleys in Tp 64, Rg 5, the Muriel Lake Formation lies at an elevation which is atypically higher than the elevation of the deposits elsewhere in the valley. In fact, as the elevation of the regional topography decreases eastward, the elevation of the formation increases, from 530 m at the confluence (testhole E803, Figure 5) to about 545 m directly west of Cold Lake in Tp 65, Rg 2 (Figure 8, x-sec E1-E1',testhole E767). The formation is the thickest in the northeast part of the map area (Tp 65, Rg 2), locally consisting of as much as 58 m of clay, sand, and gravel (Figure 20).

The second trend of deposits of the Muriel Lake Formation originates along the northwest end of the Helina Valley and extends southeast, following the orientation of the Bronson Lake and Big Meadow Valleys (Figure 19). Data are lacking for the northwest part of this second trend, and it is uncertain if the formation is absent between Tp 67, Rg 13, and Tp 65, Rg 11, as shown in figure 19, or, if it is continuous. The formation is thick along the thalweg of the central segment of the Helina Valley, locally consisting of as much as 45 m of clay, sand and gravel (Figure 20), but thins (<5 m) along the flanks.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66
65
64
63
62
61
60
59
58
Imperial Mills
Lac La Biche
Saddle River
Cold Lake
Muriel Lake
Kikino Valley
28
W4M

Figure: 20 Thickness of clay, silt, sand and gravel in the Muriel Lake Formation.
Note the extensive, thick deposits along the buried Helina, Bronson Lake and Big Meadows Valleys.

▨ Sand and Gravel

▨ Clay, Silt, Sand and Gravel

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - - -
Isopach, Interval 10 metres .... ═ 50 ═
Data Location .... ●
Thalweg .... ▬ ▬ ▬

The Muriel Lake Formation extends out of the Helina Valley in Tp 63, Rgs 7-10, as a thin drape overtop the flat-lying bedrock as far south as Tp 61, Rg 10 (Figure 20). A narrow band of the formation also extends south of Tp 63, Rg 8, and connects the deposits in the Helina Valley with those in the Beverly Valley (Figure 19). Within this band the formation lies in a depression, which likely represents an erosional channel that truncated the interfluve between the Helina and Beverly valleys. This channel extends both northward, beneath the Sand River (Figure 8, 8, x-sec E3-E3' testhole E832), and southward, connecting with the Kehiwin Lake Valley (Figure 4).

Similarily, the Muriel Lake Formation lies within another band which extends east of the Helina Valley in Tp 62, Rg 7, and which connects the deposits in the Helina Valley with those in the Bronson Lake and Big Meadow Valleys (Figure 19). Figure 20 shows that within the western segment of the Bronson Lake Valley the Muriel Lake Formation consists of as much as 28 m of sand and gravel. Data are absent for the eastern portion of the Bronson Lake Valley, but the formation is projected to extend east to connect with those deposits which lie within the Vermilion Valley (Figure 19).

The Muriel Lake Formation extends south, out of the confines of the Bronson Lake Valley, to lie within a widespread cover overtop the bedrock in Tp 60, Rgs 4-5 (Figure 19). In this area the unit forms a thick deposit which extends about 12 km in an east-west direction (Figure 20). The configuration of this deposit suggests that it may represent a high level terrace along the south edge of the Bronson Lake Valley.

It is believed that the Muriel Lake Formation lies at the base of most of the Big Meadow Valley, resting either directly on the bedrock floor, or on top of unit 3 of the Empress Formation. The Bronson Lake Formation, which normally separates the two sand and gravel units, appears to have been eroded within this valley. The formation extends southeast as a widespread cover on top of the bedrock interfluve between the Big Meadow and Vermilion Valleys (Figure 19).

Differentiation from other Formations

The Muriel Lake Formation has abundant clasts derived from the Canadian Shield and this differentiates it from unit 1 of the Empress Formation. On the basis of clast composition alone however, the Muriel Lake Formation cannot be easliy differentiated from the other stratified units of Quaternary age. Stratigraphic position is the most reliable means to differentiate the formation from these units. As an example, although the Muriel Lake Formation and unit 3 of the Empress Formation have a similar lithology, they can be differentiated with relative ease where they are separated by clayey till of the Bronson Lake Formation (Figure 8, x-sec E2-E2', testhole E1712). In the situation that the Bronson Lake Formation has been eroded or is absent, the presence of the two stratified units can still be inferred. For example, in testhole E1937 (Figure 5), located above the Bronson Lake Valley in Tp 60, Rg 3, the basal sand and gravel unit, which on the basis of stratigraphic position can be considered to be unit 3, is thicker, and lies at a higher elevation, than known unit 3 deposits in the western part of the valley. The Bronson Lake Formation, normally overlies unit 3 in the west, is not recognized in this testhole. This suggests that here, the Bronson Lake Formation was and the Muriel Lake Formation was deposited on top of the Empress Formation. Admittedly, the exact contact between the units at this site cannot be easily determined.

In those places where the base of the Muriel Lake Formation consists of clay, it is to differentiate from the Bronson Lake Formation (Figure 8, x-sec E1-E1', testholes E1720 and E767).

The Muriel Lake Formation Formation is differentiated from the overlying Ethel Lake Formation primarily by stratigraphic position. The Muriel Lake Formation is generally thicker and contains less silt and clay. As well, the two units are commonly separated by glacial sediment of the Bonnyville Formation.

Nature of Contacts

In those places where sand and gravel of the Muriel Lake Formation overlie diamicton of the Bronson Lake Formation, the contact is sharp (Figure 8, x-sec E2-E2', testholes E1708 and E1712). Conversely, where the base of the Muriel Lake Formation is composed of clay and silt, the contact with the Bronson Lake Formation is difficult to establish, as shown in testholes E767, E833 (Figure 5) and E1720 (Figure 10).

Generally the upper part of the Muriel Lake Formation is composed of sand, or sand and gravel, and the contact with diamicton of the overlying Bonnyville Formation is sharp, as shown in testholes E1708 and E1712 (Figure 5).

Origin

It is believed that not all deposits within the Muriel Lake Formation have the same origin and that all were not deposited during the same event. The thick, extensive clay, which lies at or near the base of the formation in a number of locations within the Helina Valley (Figure 5, testholes E833, E831, E1720, E765), is believed to have a glaciolacustrine origin, deposited on top of the Bronson Lake Formation from proglacial lakes which formed in the valley during the retreat of the Cherry Grove Glacier. In other areas, where the clay is much thinner and is interbedded with sand and gravel, it is interpreted to have a been deposited in a fluctuating fluvial or glaciofluvial environment, likely near the glacier margin (Figure 5, testholes E829, E802, E804).

It is probable that most, though not all, of the sand and gravel of the Muriel Lake Formation represents glaciofluvial sediment deposited during the retreat of the Cherry Grove Glacier. The evidence that these are glaciofluvial deposits, rather than glaciolacustrine, is that firstly, the deposits have a channel-like configuration, and lie mainly within the buried bedrock valleys, and secondly, that they are generally thick. The evidence that most of the Muriel Lake Formation was deposited during the retreat of the Cherry Grove Glacier, rather than during the advance of the Fort Kent glacier, is somewhat indirect. Within segments of the buried valleys, and on the upland south of the Bronson Lake Valley, the underlying Bronson Lake Formation is well preserved and extensive. The reason offered to explain this is that the formation was protected from erosion, during the following nonglacial period, by thick sequences of the overlying sand and gravel of the Muriel Lake Formation. It is inferred therefore, that the deposition of the gravel preceeded the nonglacial period which followed, and thus was associated with the retreat of the Cherry Grove Glacier, rather than with the advance of the Fort Kent Glacier.

There is stratigraphic evidence to show that in the northeast segment of the Helina Valley, between Tp 65, Rg 2 and Tp 64, Rg 5, the Muriel Lake Formation was deposited in-contact with an ice margin during either the retreat of the Cherry Grove Glacier or, during the advance of the Fort Kent Glacier. The evidence for this is that the top of the formation lies at a significantly higher elevation within this segment of the Helina Valley than it does in the western portions of the valley, even though the regional slope is to the northeast. This anomalously higher elevation of the formation can be explained by depostion from meltwater flowing from a high relief glacier front. Interestingly, this thick sequence of sand and gravel forms the core of the Medley River Upland physiographic unit in the northeast part of the map area (Figure 8, x-secs E1-E1' and E2-E2').

VII. BONNYVILLE FORMATION

Source of name: Town of Bonnyville located in Tp 61, Rg 5, W4M in the Sand River map area NTS 73 L.

Type section: Alberta Geological Survey auger testhole T-43, located in LSD 16, Sec 26, Tp 61, Rg 7, W4M (Figure 21).

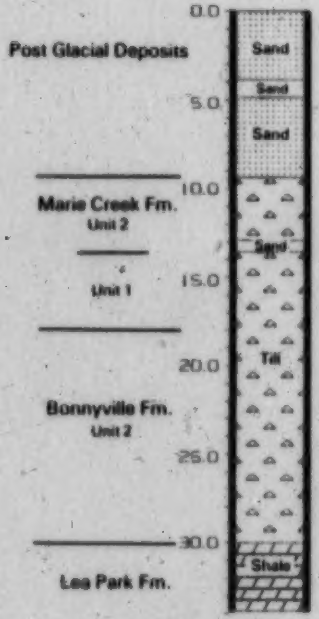
Type area: The area around the town of Bonnyville, in the east central part of the Sand River map area NTS 73 L.

Reference sections: Alberta Geological Survey auger testholes T-16 (LSD 4, Sec 30, Tp 61, Rg 1, W4M), T-32 (LSD 9, Sec 2, Tp 64, Rg 3, W4M), Alberta Environment rotary testholes E802 (LSD 4, Sec 32, Tp 61, Rg 5, W4M), E1710 (LSD 16, Sec 9, Tp 62, Rg 5, W4M), E1708 (LSD 4, Sec 14, Tp 62, Rg 5, W4M).

A. Description of Formation

The Bonnyville Formation is extensive throughout the map area. It has not been observed in outcrop, but has been mapped from dry-auger flite samples, rotary drill cuttings, sidewall samples, and electric logs. The formation consists primarily of diamicton which is characterized by an abundance of quartz in the very coarse sand fraction, and by a paucity of calcareous material, particularily dolostone and dolomite, in the very coarse sand and silt-clay fractions. On the basis of differences in matrix texture and electric log responses, the Bonnyville Formation is divided into two units: unit 1, a clayey, low resistive diamicton, which is overlain by unit 2, a sandy, highly resistive diamicton. In places stratified sediment consisting of clay, sand and gravel, lies between diamicton of units 1 and 2 (Figure 23). This sediment is included as part of unit 1. Figure 22 shows the electric and gamma ray log characteristics of this stratified sediment as well as the diamicton of both units 1 and 2. The two units of the Bonnyville Formation are described separately below.

T43



Alberta Geological Survey Testhole T 43
Location of LSD 16 Sec 26 Twp 61 Rng 7 W of 4 Mer . NTS 73L
Elevation 1800 Ft 549 M Source 1:50,000 NTS 73L/7
Date drilled 197608 26 Logged by M FENTON

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)					
DEPTH (M)	SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	TGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH
10.00	40.1	23.7	36.2	44.0	26.8	29.2	1.90	13.8				67.5	26.2	0.8	2.5	2.5	0.4	0.0
11.00	35.8	31.1	33.1	39.9	32.6	27.4	2.46	11.7				55.7	20.1	0.0	5.7	16.2	2.2	0.0
12.00	39.5	35.1	25.4	44.4	33.5	22.2	2.52	9.9				60.5	18.8	0.3	3.9	13.6	2.9	0.0
13.00																		
14.00	37.3	24.7	38.0	40.9	26.6	32.6	2.85	9.9				61.9	26.6	0.0	3.0	7.6	0.8	0.0
15.00	34.5	26.5	39.0	37.8	29.4	32.8	2.30	10.0				64.9	18.4	0.3	5.5	9.5	1.5	0.0
16.00	34.0	25.3	40.8	37.5	27.3	35.3	2.35	10.2				62.0	25.1	0.6	3.7	8.1	0.6	0.0
17.00	28.8	29.4	41.8	32.1	33.8	34.2	1.84	12.1				59.3	24.5	0.8	5.5	8.5	1.2	0.0
18.00	53.0	27.7	19.3	56.7	26.5	16.9	3.52	8.3				57.3	33.1	1.5	3.5	2.2	2.2	0.0
19.00	52.5	28.2	19.2	56.2	27.5	16.2	3.02	8.4				58.3	33.2	0.5	5.7	1.5	0.4	0.0
20.00	54.0	27.9	18.1	57.7	28.6	13.7	3.70					60.3	29.5	2.1	4.5	1.5	1.7	0.0
21.00	54.1	27.1	18.8	58.0	27.1	14.9	3.49	8.5				58.2	34.4	1.1	3.2	1.3	1.5	0.0
22.00	53.5	27.3	19.2	57.2	27.2	15.6	3.57	9.3				54.2	35.1	1.1	5.6	1.9	0.7	0.0
23.00	51.4	26.7	21.9	55.1	26.3	18.5	2.77	9.7				58.0	32.4	0.3	3.7	1.9	3.3	0.0
24.00	52.3	25.7	22.0	55.8	26.8	17.4	3.35	8.9				55.4	33.3	1.2	3.5	4.2	2.6	0.0
25.00	52.3	27.5	20.2	55.9	27.0	17.0	3.31	8.8				59.4	31.9	0.5	3.7	2.7	1.6	0.0
26.00	53.1	26.1	20.8	56.7	26.0	17.2	3.19	9.4				54.9	34.7	1.0	4.2	1.7	8.6	0.0
27.00	45.3	23.1	31.6	48.7	23.7	27.6	2.60	12.2				59.3	30.2	0.6	3.7	3.7	2.4	0.0
28.00	32.8	18.8	48.3	35.3	22.8	41.9	1.72	14.0				62.9	27.2	0.0	1.8	4.5	3.6	0.0
29.00	56.0	30.0	14.0	59.9	28.9	11.3	2.95	8.8				65.0	26.8	0.5	3.2	2.4	2.1	0.0

Figure: 21 Type section of the Bonnyville Formation. Alberta Geological Survey testhole T 43 (LSD 16 Sec 26 Tp 61 Rg 7 W4M).

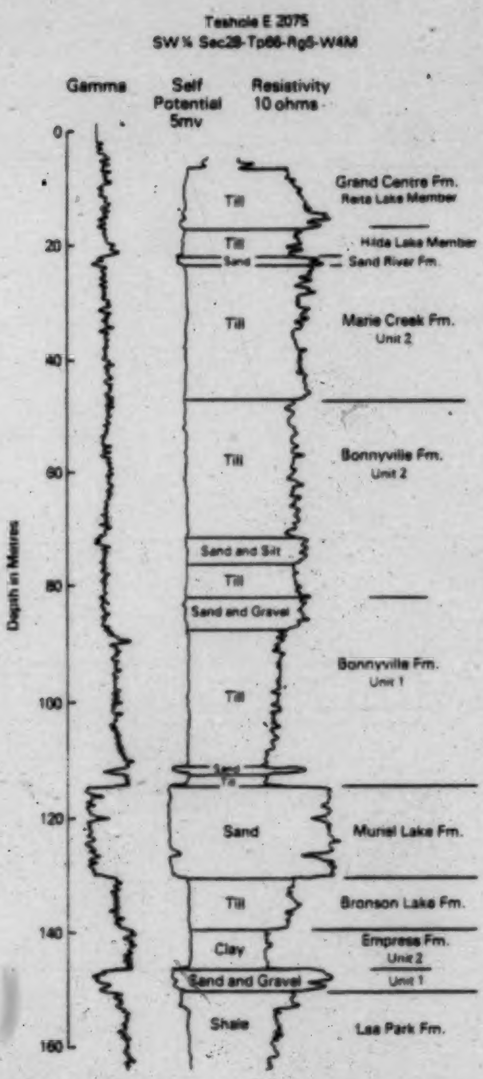


Figure:22 Electric and gamma ray log responses of units 1 and 2 of the Bonnyville Formation. Alberta Environment testhole E 2075 (LSD 4 Sec 28 Tp 66 Rg 5 W4M).

B. Unit 1

Description of unit

Unit 1 of the Bonnyville Formation is recognized primarily from the electric logs, though some samples of the diamicton have been analysed by Gold and in this study (Appendix A, testholes T-23, T-38, and T-73). In these testholes unit 1 consists of a clayey, dark grey diamicton which has an average matrix texture of about 28% sand, 30% silt, and 42% clay (Table 2). The textural variations range between 25% to 35% sand, 25% to 35% silt, and 41% to 44% clay (Table 4).

The composition of the very coarse sand fraction consists of about 61% igneous and metamorphic rock types, 33% quartz fragments, 3% limestone, 2% dolostone, and about 1% local rock types (Table 2). The variations range between 58% to 64% igneous and metamorphic rocks, 30% to 36% quartz fragments, 2% to 4% limestone, 1% to 3% dolostone (Table 4).

Calcareous material makes up 3% of the silt-clay fraction (Gold, 1978, testhole E798).

Distribution, Thickness and Subcrop Topography

Unit 1 of the Bonnyville Formation is not extensive within the map area, but lies only within segments of the Beverly, Helina, Vegreville, Sinclair, and Holyoke Valleys (Figure 23). The top of the unit ranges in elevation from as much as 606 m in the southwest in Tp 58, Rg 10, to as low as 515 m near Trueman in Tp 63, Rg 8 (Figure 23).

Beverly and Vegreville Valleys

The most extensive deposit of unit 1 is in the southwest corner of the map area, overlying a segment of the Beverly and Vegreville Valleys in the area defined by Tps 58-60, Rgs 8-14. Within much of this area unit 1 is overlain by unit 2 except for the extreme western part where unit 2 is believed to have been eroded and where unit 1 forms the top of the formation. The thickest deposits of unit 1 are found in the western segment of the valley near Spedden in Tp 59, Rg 13, where as much as 68 m have been mapped. (Figure 24).

Table 4. Properties of unit 1 of the Bonnyville Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy												Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dol. %		Qtzite & Qtz. Sst. %		Local %		CO₂ %		Calcite Dolomite %	
			x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
T33	15-22-64-8-W4M	10	29	1	44	2	1.4	2	11	8	50	4	38	4	2	1	1	8	6	5	9	6				
T36	4-36-64-7-W4M	10	32	2	35	2	1.4	2	11	6	50	5	34	5	4	1	3	1	8	5	1	2				
		2	28	1	41	2	1.2	1	12	2	50	3	36	3	3	6	2	1	6	6	1	9				
T75	9-6-65-7-W4M	5	38	2	41	1	2.1	1	11	4	54	3	30	2	3	5	3	1	2	2	11	6				
77SR21	13-18-63-12-W4M	6	21	3	47	4	1.1	1	16	4	54	4	29	4	3	1	2	1	6	4	13	9				
Mean of the mean values from all testholes			28	6	42	4	1.4	4	12	1	51	3	33	3	3	1	3	1	5	2	10	8				
Total number of samples -n			n = 34		n = 34		n = 34		n = 34		n = 34		n = 34		n = 34		n = 34		n = 34		n = 34					
Total number of testholes -N			N = 4		N = 4		N = 4		N = 4		N = 4		N = 4		N = 4		N = 4		N = 4		N = 4					

x̄ - Mean
S.D. - Standard Deviation

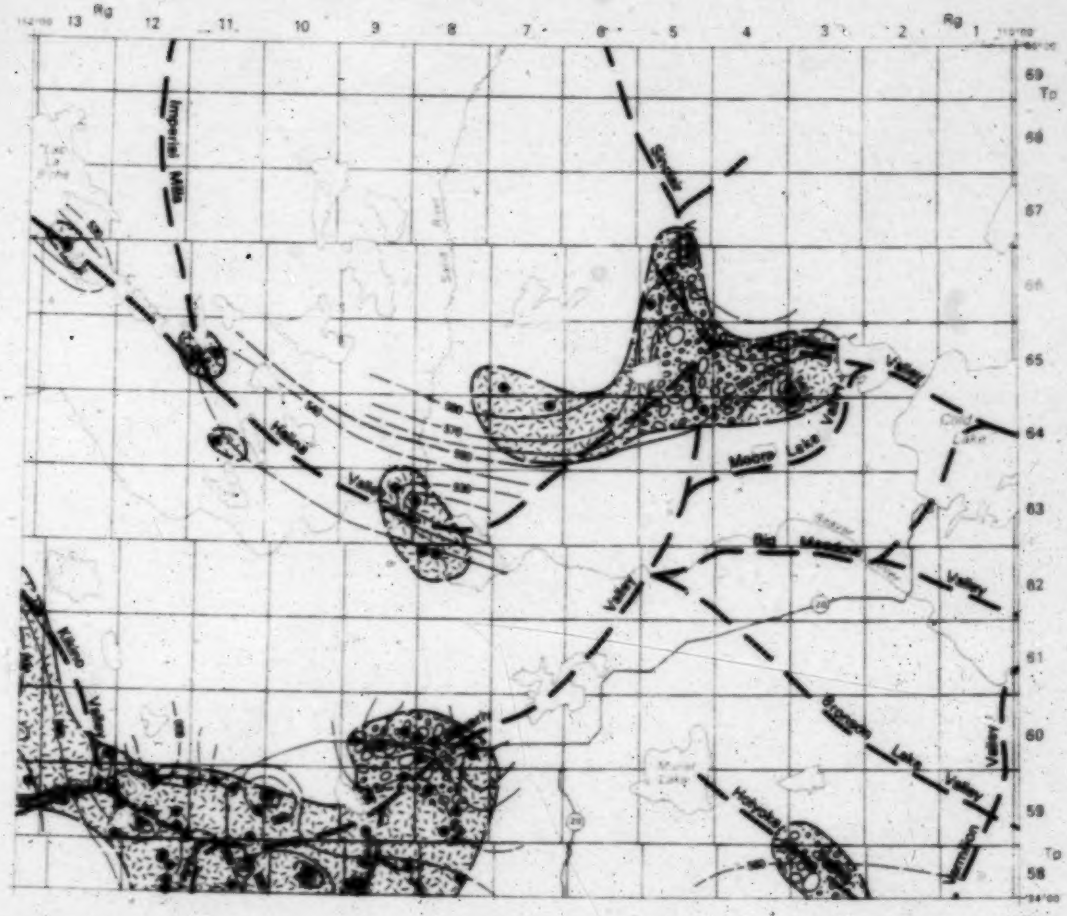

Rg
13
12
11
10
9
8
7
6
5
4
3
2
1
Tp
69
68
67
66
65
64
63
62
61
60
59
58
Imperial Mills
Helina
Valley
Moore Lake Valley
Big Meadow
Valley
Valley
Kikino
Valley
Cold Lake
Muriel Lake
Lake
Valley
Valley
Vermilion
580
570
560
530
W4M

Figure:23 Elevation of the upper surface of unit 1 of the Bonnyville Formation.

Note the distribution of unit 1 adjacent to and above segments of the buried Helina and Beverly Valleys.

▨ Sand and Gravel

▨ Diamicton (till)

Unit Boundaries:
Approximate
Assumed
Contours, Interval 10 metres:
Defined
Approximate
Data Location ●
Thalweg

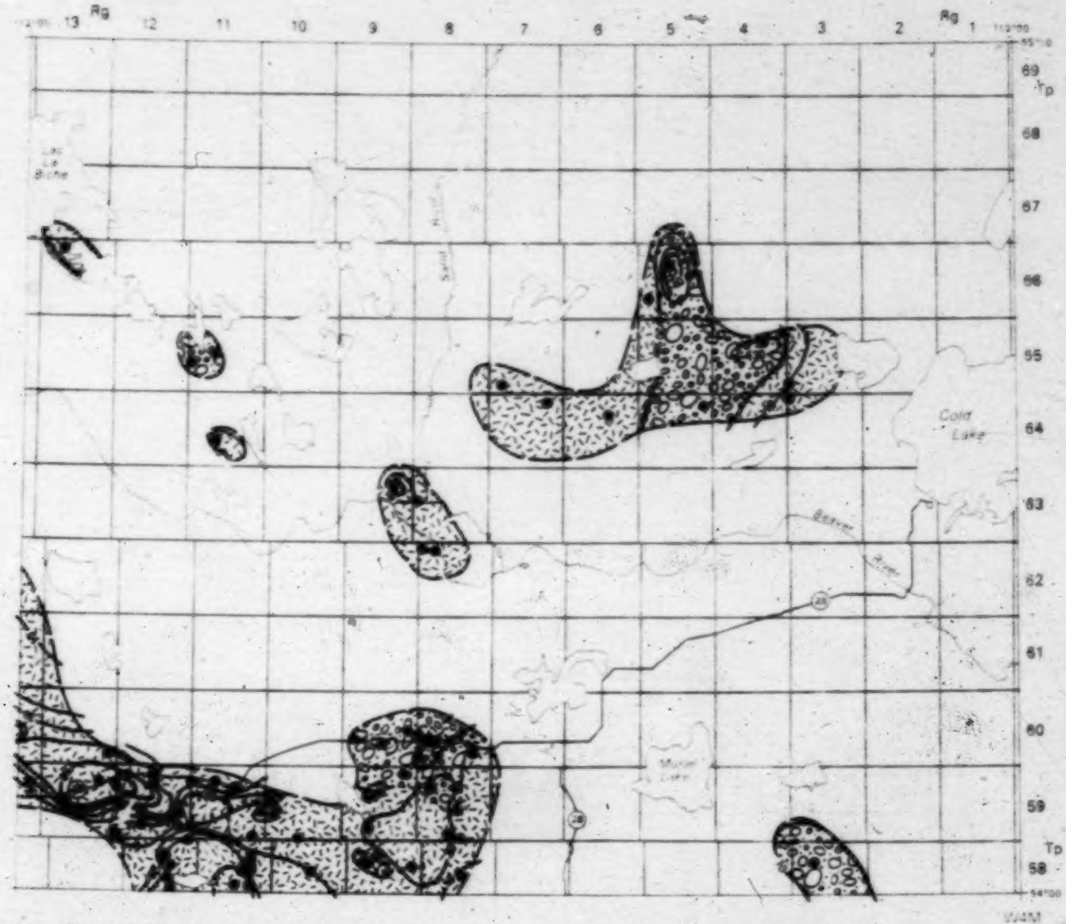

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
28
W4M

Figure: 24 Thickness of diamicton and stratified sediment in unit 1 of the Bonnyville Formation.
Note the very thick deposits in township 59, ranges 12 to 14.

▨ Sand and Gravel

▨ Diamicton (till)

Unit Boundaries:
Approximate..................... ——
Assumed......................... - - -
Isopach, Interval 10 metres.......... ═
Data Location....................... ●

Unit 1 thins to about 20 m in the northeast segment of the deposit in Tps 59-60, Rgs 8-9. In this area unit 1 consists of diamicton overlain by as much as 10 m of stratified sand and clay (Figure 25).

Helina and Sinclair Valleys

Unit 1 forms discontinuous deposits within segments of the Helina Valley and its northern flank, and within the southern end of the Sinclair Valley (Figure 24). Evidence of the discontinuous distribution is shown in Tp 65, Rg 11, where, in ten nearby testholes, unit 1 is recognized within only three. The most extensive deposit of unit 1 in the Helina Valley, is mapped in the northeast corner, defined by Tp 64-65, Rg 3-8 (Figure 24). Here, stratified sediment covers the diamicton over a considerable area (Figure 23). Unit 1 also extends northward from the Helina Valley into the Sinclair valley in Tps 66-67, Rg 5 and onto the uplands flanking the north slope of the Helina valley in Tps 64-65, Rgs 6-7 (Appendix A, testholes T-23, T-38, T-73).

The thickness of unit 1 varies considerably in the Helina Valley and its tributaries, ranging from as little as 3 m in Tp 63, Rg 8, to as much as 41 m in the Sinclair valley in Tp 66, Rg 5 (Figure 24). In places within the valley 16 m of clay, sand and gravel overlie 27 m of diamcton. (Figure 8, x-sec E2-E2',testhole E2075).

Holyoke Valley

Unit 1 is believed to lie within the Holyoke valley in the southeast corner of the map area although the extent of the unit is uncertain. In testhole E1721 (Figure 8, x-sec E1-E1'), unit 1 consists of about 18 m of clay and diamicton overlain by 7 m of sand (Figure 24).

Differentiation from other units

Diamicton of unit 1 of the Bonnyville Formation is differentiated from the underlying Bronson Lake Formation primarily on the basis of stratigraphic position. If the two units are not separated by stratified sediment of the Muriel Lake Formation, the differentiation is difficult because both have a similar texture and electric log response (Figure 22, testhole E2075). Their differentiation is particularly difficult in the southwest corner of the map area because the distribution and western limit of the Bronson Lake Formation is poorly known.

Generally the differences in the resistivity responses prove to be the most useful criteria for differentiating unit 1 from the overlying unit 2 of the Bonnyville Formation. Diamicton of unit 1 has a much lower resistivity response than unit 2, presumably because it is more clayey (Figure 22). As well, the data show that locally the matrix carbonate values of unit 2 are higher than those of unit 1 (Gold, 1978, testhole E798).

Nature of contacts

Lower Contact

In many places unit 1 disconformably overlies shale and siltstone of the Belly River and Lea Park Formations. Commonly this contact is gradational and difficult to recognize because the diamicton of unit 1 contains a significant amount of incorporated bedrock material. Recognizing this contact is particularily difficult in Tp 59, Rg 13 around Spedden (Figure 9, x-sec N2-N2', Chorney water-well drill log, LSD 9, Sec. 28, Tp 59, Rg 12). Where unit 1 overlies stratified deposits of the Muriel Lake and Empress Formations the contact is sharp and well defined on the electric logs (Figure 22).

Upper Contact

The upper contact of unit 1 with the base of unit 2 is considered to be conformable and can be either gradational, (Appendix A, testhole T-38) or sharp, (Figure 5, testhole E798). In a number of locations above segments of the buried Beverly and Helina valleys, the contact between the two units is well defined by the stratified sediment of unit 1, which separates the diamicton of the two units (Figure 8, x-sec E2-E2',testholes E831, E2075).

In the southwest corner of the map area unit 1 is overlain by stratified deposits of the Sand River Formation, and diamicton of the Kehiwin Lake Member of the Grand Centre Formation. In both cases the contact is generally sharp and well defined on the electric logs (Figure 9, x-sec N1-N1', water-well testhole LSD 9, Sec. 28, Tp 59, Rg 12, W4M).

C. Unit 2

Description of unit

Unit 2 consists of a diamicton which, in most places, is unoxidized very dark grey (5Y 3/ 1). In a number of places in the west part of the map area it is oxidized olive brown (2.5Y 4/3).

In the east unit 2 is very sandy, with an average matrix texture of about 48% sand, 28% silt, and 24% clay (Table 2). The textural variations range between 45% to 53% sand, 22% to 30% silt and 17% to 25% clay (Table 5 and Figure 25). The matrix is relatively rich in granules and coarse sand (about 3%, Table 2), and pebbles and cobbles are common. The sandy texture is also expressed by a low moisture content, ranging between 9% and 11%. In the east the unit is easy to penetrate with a dry auger, and samples are generally loose and crumbly on the dry-auger flites.

In the west part of the map area unit 2 is less sandy and contains more clay (Figure 25). Here, the average matrix texture consists of about 36% sand, 33% silt, and 31% clay (Table 2). The textural variations range between 32% to 39% sand, 30% to 40% silt, and 25% to 36% clay (Table 5 and Figure 25). The greater amount of clay in unit 2 in the west yields a slightly higher moisture content, ranging between 9% and 13%, and causes the unit to be stiffer and more difficult to penetrate with a dry-auger.

The composition of the very coarse sand fraction of unit 2 is much the same throughout the map area. The average values, shown in Table 2, consist of about 58% igneous and metamorphic fragments, 34% quartz fragments, 3% limestone, 2% dolostone, less than 1% quartzite, and between 1-2% locally derived bedrock fragments. The variations range between 52% to 60% igneous and metamorphic rock fragments, 32% to 40% quartz fragments, 3% to 5% limestone fragments, and 1% to 3% dolostone fragments, and .5% to 3% local rock fragments (Table 5).

Calcareous material makes up 5% to 12% of the silt-clay fraction, with dolomite more abundant than calcite (calcite/dolomite ratio = .37, Table 2).

The clay mineralogy was determined for a few samples of the sandy facies of unit 2. The mineralogy consists of 40% to 50% illite, 25% to 40% kaolinite, 17% to 25% montmorillonite, and 5% to 10% chlorite (Appendix B).

Table 5. Properties of unit 2 of the Bonnyville Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy												Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dol. %		Chert & Qtz. Sst. %		Local %		CO_3 %		Calcite Dolomite %	
			x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.	x	S.D.
T5	2-18-59-3-W4	4	38	2	38	1	2.0	4	11	1	58	4	32	4	4	1	2	1	1.7	8	1.7	8	9	1	38	08
T6	15-31-62-3-W4	7	50	4	24	2	3.4	4	9	4	57	2	30	2	4	2	4	1	1.0	6	2.5	3	12	1	40	08
T9	13-10-62-2-W4M	6	43	4	28	4	2.8	2	9	8	58	4	30	3	6	1	2	1	1.8	8	1.8	4				
T10	9-18-63-4-W4M	2	48	2	14	3	3.2	4	11	6	68	2	22	2	4	1	3	5	3	4	1.8	1				
T11	9-14-62-5-W4M	11	53	2	22	3	2.9	3	12	8	60	3	32	3	3	1	2	1	8	5	1.5	8				
T12	4-4-62-4-W4M	28	51	4	23	3	3.1	5	11	6	60	4	32	4	4	1	2	1	2	2	1.5	7				
T13B	1-30-60-2-W4M	6	47	6	28	3	2.4	4	9	1	60	3	32	3	3	1	2	1	5	5	1.5	8				
T15	16-20-60-1-W4M	2	53	1	17	1	3.3	2	11		58		38		3		2		4		2.2					
T16	4-30-61-1-W4M	4	51	4	22	1	2.8	3	8		57	2	34	3	4	3	3	1	2	2	2.2					
T17	7-36-61-3-W4M	7	43	5	33	5	3.7	5	10	2	56	2	37	4	3	1	2	1	1.3	1.0	1.8	1				
T18	9-18-61-3-W4M	3	51	2	34	2	2.8	5	11	5	63	3	31	3	4	4	2	1	4	4	7	3				
T19	16-30-64-2-W4M	18	48	3	24	2	3.0	3			52	4	41	3	2	1	1	8	1.1	6	1.6	7				
T20	7-28-64-5-W4M	27	48	1	31	1	2.8	2	9	4	66	3	29	2	2	1	3	1	2	2	8	4				
T22	7-19-65-5-W4M	7	41	3	29	2	2.4	5	11		61	6	41	3	3	2	3	2	5	6	3	2.3				
T23	15-22-64-6-W4M	7	48	3	28	2	2.5	2	10	5	50	3	40	4	4	1	3	8	2	2	1.2	7				
T25	4-24-63-6-W4M	7	59	4	17	3	3.7	1.0	10	1	54	1	38	2	3	1	3	1	2.9	1.0	5	2	12	1	25	08
T27	4-9-64-3-W4M	6	48	2	24	2	3.2	2	9		61	2	28	1	4	1	3	1	4	3	2.4	1.0				
T30	13-4-62-2-W4M	10	52	3	26	2	3.3	4	8	1	58	2	32	3	4	1	3	5	5	3	1.8	8	12	1	26	06
T32	12-1-64-3-W4M	10	53	1	20	2	3.4	2	9	4	58	3	36	2	2	1	1	5	1.3	7	1.7	8	8	1	32	08
T33	5-32-65-1-W4M	6	45	3	24	4	2.8	5	11	1	58	3	34	2	5	1	2	8	3	2	2.5	3	13	3.3	25	02
T34	13-18-63-2-W4M	5	48	4	28	1	3.5	2	10	5	58	1	34	2	4	1	4	1	8	1	2.5	1				
T38	4-36-64-7-W4M	10	46	2	28	3	3.4	2	11	4	58	4	33		3	1	3	1	6	5	1.6	6				
T40	4-29-62-8-W4M	1	58		18		3.4		10		57		37		3		2		0		1.8					
T41	3-29-58-3-W4M	18	43	2	23	1	2.8	2	10	3	60	4	32	3	3	1	3	1	4	5	2.3	9				
T42	16-28-61-7-W4M	11	53	1	20	1	3.2	4	9	5	58	2	33	2	4	1	3	1	9	6	2	1.0				
T44	14-24-61-8-W4M	3	46	2	27	4	3.2	4	9	2	58	1	38	2	1	1.5	2	2	2.3	2	8	8				
T47	12-36-60-8-W4M	2	40	2	29	6	1.9	1	10	2	52	6	40	4	5	2	1		2.3	5	6	3				
T52	3-5-60-4-W4M	2	48	3	25	1	2.7	3			58	2	35	4	5	2	2	1	1.3	5	1.8	1.2				
T53	4-21-61-4-W4M	6	54	6	19	6	3.3	8	9	6	58	4	34	4	3	1	3	1	3	2	1.2	8				
T58	16-13-63-2-W4M	12	51	2	22	2	3.0	3	8	1	58	3	30	3	4	1	3	1	5	4	2.4	6	14	1	29	08
T59	1-21-63-3-W4M	7	48	1	24	1	3.8	2	9	2	58	3	30	4	5	1	4	4	7	4	2.8	5	10	3	37	1
T71	9-25-59-8-W4M	9	42	2	31	2	2.5	2	11	5	58	3	33	2	4	1	3	1	2	2	2.0	8				
T73	9-6-65-7-W4M	10	38	2	33	2	2.3	3	10	3	63	4	29	3	3	1	3	1	4	5	1.3	8				
77SR1	1-28-58-8-W4M	23	34	8	19	3	1.7	6	12	2	58	4	32	5	3	1	3	2	6	3	1.3	1.2				
77SR2	14-17-58-7-W4M	6 2	43 32	1 2	17 38	2 4	1.6 1.6	3 0	10 11	2 3	58 66	4 2	38 28	4 1	1 4	6 1	2 1	6 7	1.8 4	8 2	1.2 1.4	8 6	8 9	1	37 17	1
77SR3	16-10-58-10-W4M	10	48	2	15	2	2.4	3	11	4	52	5	42	5	2	1	1	1	1.1	.7	1.1	8	6	1	46	4
77SR7	16-29-58-11-W4M	9	37	3	38	4	1.4	1	12	1	54	4	37	3	4	1	3	1	9	8	1.9	8				
77SR11	1-6-59-10-W4M	5	46	2	28	1	2.5	2	9	4	68	4	24	4	2	1	1	8	.5	1	1.1	5				
77SR12	1-15-60-10-W4M	1	55		23		2.4		9		52		42		3		2		0		1					
77SR15	9-16-61-13-W4M	18	38	1	32	2	1.8	.2	10	.5	60	3	32	4	3	1	2	1	1.0	.9	1.8	1				
77SR20	1-25-63-11-W4M	10	37	3	35	3	1.1	.2	10	1	48	2	48	3	1	.7	1	.7	2.8	.9	1.4	.7				
77SR21	10-18-63-12-W4M	2 6	30 33	3 2	30 34	1 2	1.4 1.2	.2 .5	12 12	 1	58 65	 3	37 28	 3	2 4	 1	1 2	 .3	.8 .8	.4 .4	1.2 1.4	 .3				
77SR23	11-29-65-10-W4M	2	45	1	28	.4	2.2	1	9	0	58	5	34	5	5	1	2	2	.6	0	.5					
77SR24	8-18-66-12-W4M	2 7	38 30	3 3	25 23	1 1	1.6 .8	.4 .1	11 13	.6 .8	61 58	5 4	32 38	6 5	1 2	.6 1	3 2	3 5	.9 1.8	.6 1	.7 1.7	.5 .4				
77SR27	2-36-67-12-W4M	7	36	3	26	1	2.4	.4	12	.6	65	5	28	5	4	1	2	2	3	3	2.1	.6				

X - Mean
S.D. - Standard Deviation

Table 6(cont'd)

	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dol. %		Qtzite & Qtz. Sst. %		Local %		CO_3 %		Calcite Dolomite %	
			X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.
77SR28	10-22-69-11-W4M	6	47	2	29	2	2.3	4	10	2	64	2	29	2	2	5	3	1	3	3	7	3				
		14	38	3	36	3	1.7	2	11	6	61	3	32	4	2	7	3	1	5	5	1.1	5				
77SR29	8-2-69-13-W4M	12	39	2	27	4	2.0	3	10	8	59	2	32	3	3	1	3	1	5	3	1.0	3				
77SR30	14-22-69-12-W4M	5	45	3	20	2	1.8	2	10	3	61	2	33	3	1	5	2	1	8	8	2.4	1				
77SR31	2-31-69-13-W4M	4	38	2	29	2	2.5	1	9	2	60	2	33	2	3	4	3	8	7	8	8	2				
77SR38	9-24-69-4-W4M	12	45	3	27	3	2.8	4	10	2	61	2	33	2	2	1	1	1	1.5	8	1.5	8	8	2	59	2
		7	47	2	24	2	1.4	1	11	3	51	4	42	4	1	5	1	5	2.1	7	2.7	6				
Very Sandy Eastern Facies																										
Mean of the mean values from all testholes			45	5	24	5	2.8	5	10	1	58	4	34	4	3	1	2	1	1.8	5	9	8	10	3	37	1
Total number of samples -n			n = 329		n = 329		n = 329		n = 329		n = 329		n = 329		n = 329		n = 329		n = 329		n = 329		n = 101		n = 101	
Total number of testholes -N			N = 41		N = 41		N = 41		N = 41		N = 41		N = 41		N = 41		N = 41		N = 41		N = 41		N = 11		N = 11	
Western Facies																										
Mean of the mean values from all testholes			38	3	31	5	1.6	5	11	1	59	5	32	5	3	1	2	1	8	4	1.4	5	8		17	
Total number of samples -n			n = 119		n = 119		n = 119		n = 119		n = 119		n = 119		n = 119		n = 119		n = 119		n = 119		n = 1		n = 1	
Total number of testholes -N			N = 11		N = 11		N = 11		N = 11		N = 11		N = 11		N = 11		N = 11		N = 11		N = 11		N = 1		N = 1	

X - Mean
S.D. - Standard Deviation

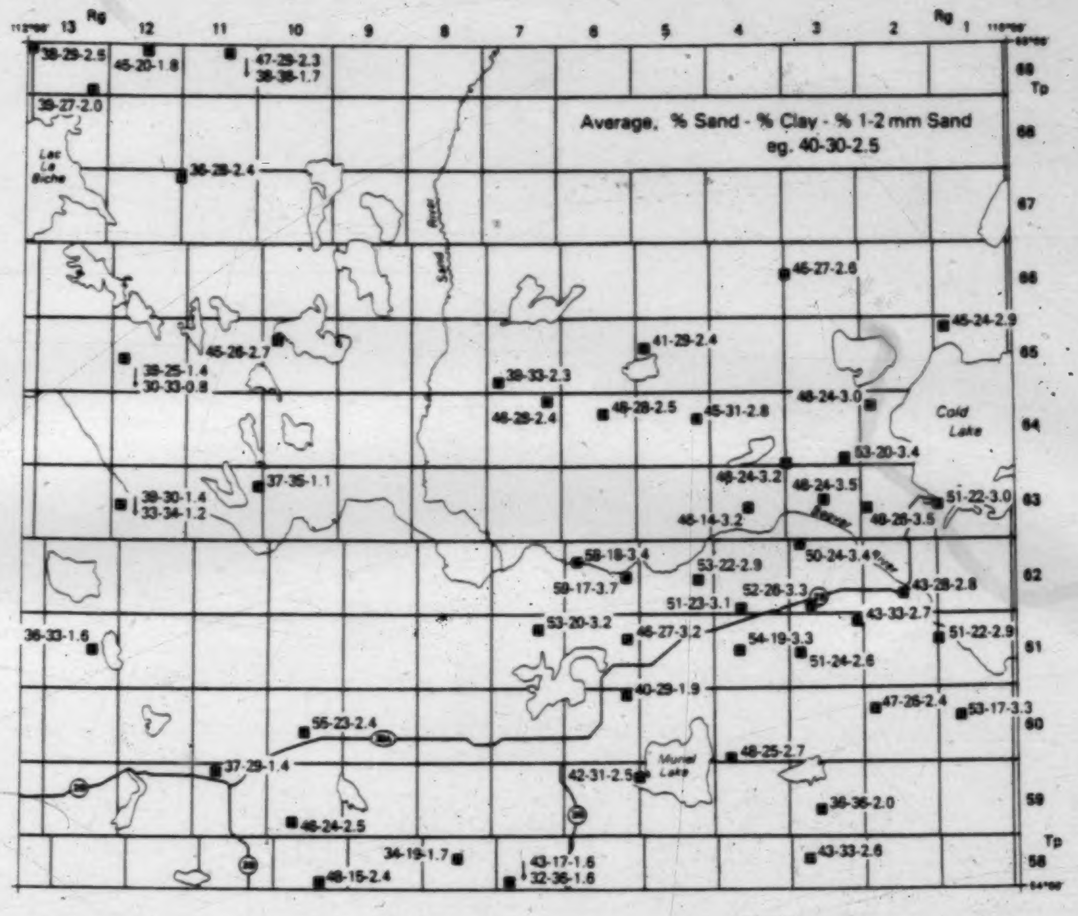

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg 1
Tp
69
68
67
66
65
64
63
62
61
60
59
Tp
58
Average, % Sand - % Clay - % 1-2 mm Sand
eg. 40-30-2.5
38-29-2.5
45-20-1.8
47-29-2.3
38-38-1.7
39-27-2.0
Lac La Biche
36-29-2.4
Sand River
46-27-2.6
45-24-2.9
41-29-2.4
45-26-2.7
39-25-1.4
30-33-0.8
39-33-2.3
46-29-2.4
48-28-2.5
45-31-2.8
48-24-3.0
Cold Lake
53-20-3.4
37-35-1.1
48-24-3.2
48-24-3.5
39-30-1.4
33-34-1.2
46-14-3.2
51-22-3.0
48-26-3.5
Beaver River
58-18-3.4
50-24-3.4
53-22-2.9
59-17-3.7
52-26-3.3
43-28-2.8
51-23-3.1
43-33-2.7
36-33-1.6
53-20-3.2
46-27-3.2
54-19-3.3
51-24-2.6
51-22-2.9
40-29-1.9
47-26-2.4
53-17-3.3
55-23-2.4
48-25-2.7
37-29-1.4
42-31-2.5
Muriel Lake
36-36-2.0
46-24-2.5
34-19-1.7
43-17-1.6
32-36-1.6
43-33-2.6
48-15-2.4

Figure: 25 Regional variations in the textural properties of unit 2 of the Bonnyville Formation.

Note the abrupt change from a very sandy texture in the east, to a less sandy texture in the west.

Distribution, Thickness and Subcrop Topography

Unit 2 of the Bonnyville Formation extends throughout most of the Sand River map area and forms the bulk of the entire formation (Figure 26). Unit 2 is absent only within a small area, a topographic low in Tp 59, Rg 11-14, in which unit 1 subcrops to form the surface of the formation. The top of unit 2 ranges in elevation from as high as 640 m in a high relief ridge in Tp 58, Rg 7, to as low as 490 m within a segment of the Big Meadow valley south of Cold Lake (Figure 26). The unit lies in a broad lowland within the Beaver River Lowland and Kehiwin Lake Upland Plains, but rises abruptly in the Marguerite Lake Upland to the north and the Reita Lake Upland to the south. It rises gently to the west, onto a low lying bench within the Lac LaBiche Upland, but falls to the northwest in Tps 66-67, Rg 13 , following the topographic low formed by the buried Helina valley (Figure 26).

Along the western margin of the Beaver River Lowland Plain, and along the present Beaver River valley in the east-central part of the map area, a northeast sloping valley lies on the surface of unit 2 (Figure 26). This valley likely represents the combinational effects of both erosion after the deposition of unit 2, and the palimpsest expression of the underlying buried Beverly and Big Meadow Valleys. Evidence for erosion is that within much of the valley the deposits are very thin, compared to outside of the valley (Figure 27). Similarily, the contour and isopach lines for the linear distribution of thin deposits extending northeast from Tp 60, Rg 12, to Tp 62, Rg 6, also suggest an erosional valley on the surface of unit 2 (Figures 26 and 27). The thickest deposits of unit 2 are found in the uplands flanking the Beaver River Lowland Plains. Here unit 2 commonly exceeds 30 m in thickness (Figure 27).

Within segments of the uplands both units 1 and 2 of the Bonnyville Formation are present. Their combined thicknesses locally exceed 40 m (Figure 8, x-sec E1-E1', E2-E2', and Figure 28). The combined thicknesses of both units also form the prominent ridge which extends from west from Tp 58, Rg 6 to Tp 58, Rg 10, along the southern boundary of the map area (Figure 26).

Differentiation from other units

Unit 2 of the Bonnyville Formation is one of the sandiest diamictons in the map area, particularily in the amount of very coarse sand (Table 2) and locally it can be

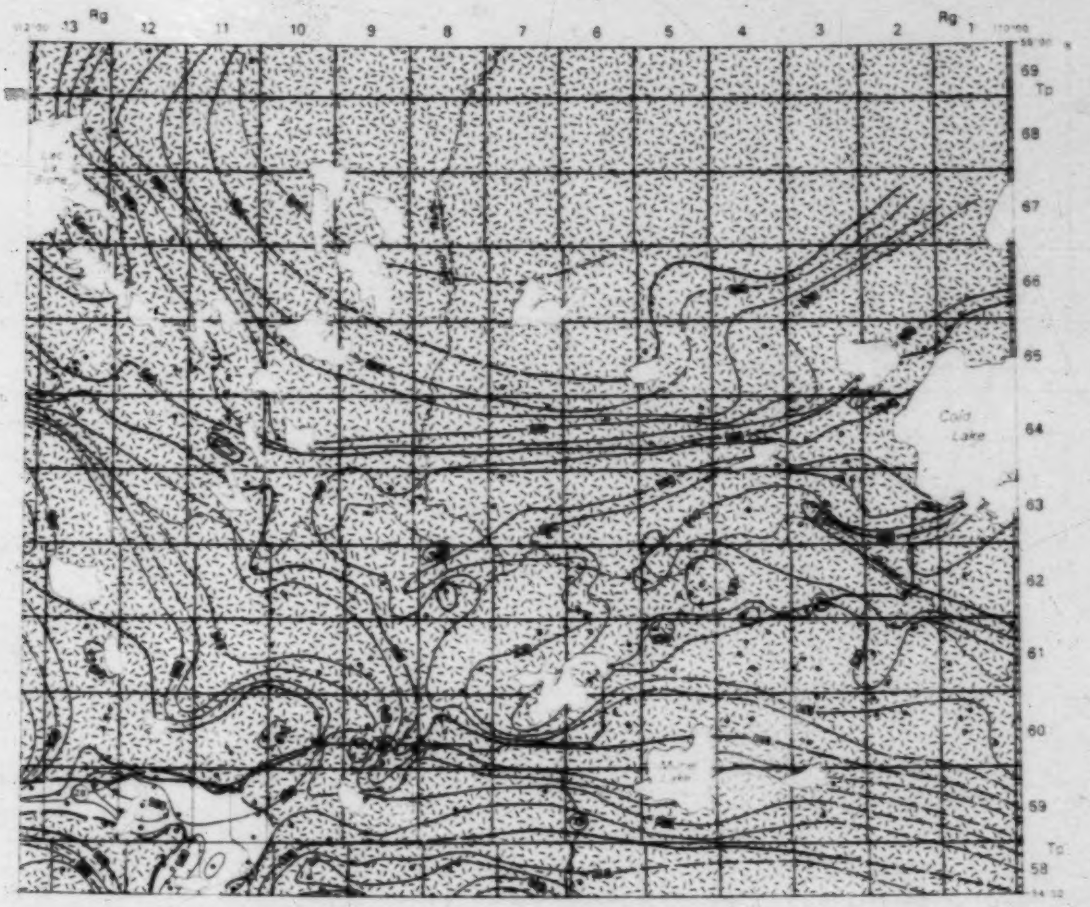

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Cold Lake
Muriel Lake
510

Figure: 26 Elevation of the upper surface of unit 2 of the Bonnyville Formation.

This figure shows all of the upper surface of unit 2, as well as a portion of the upper surface of unit 1 in the southwest where unit 2 is absent.

▨ Diamicton (till)

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - - -

Contours, Interval 10 metres:

Defined .... —— 500 ——

Approximate .... — — 500 — —

Data Location .... •

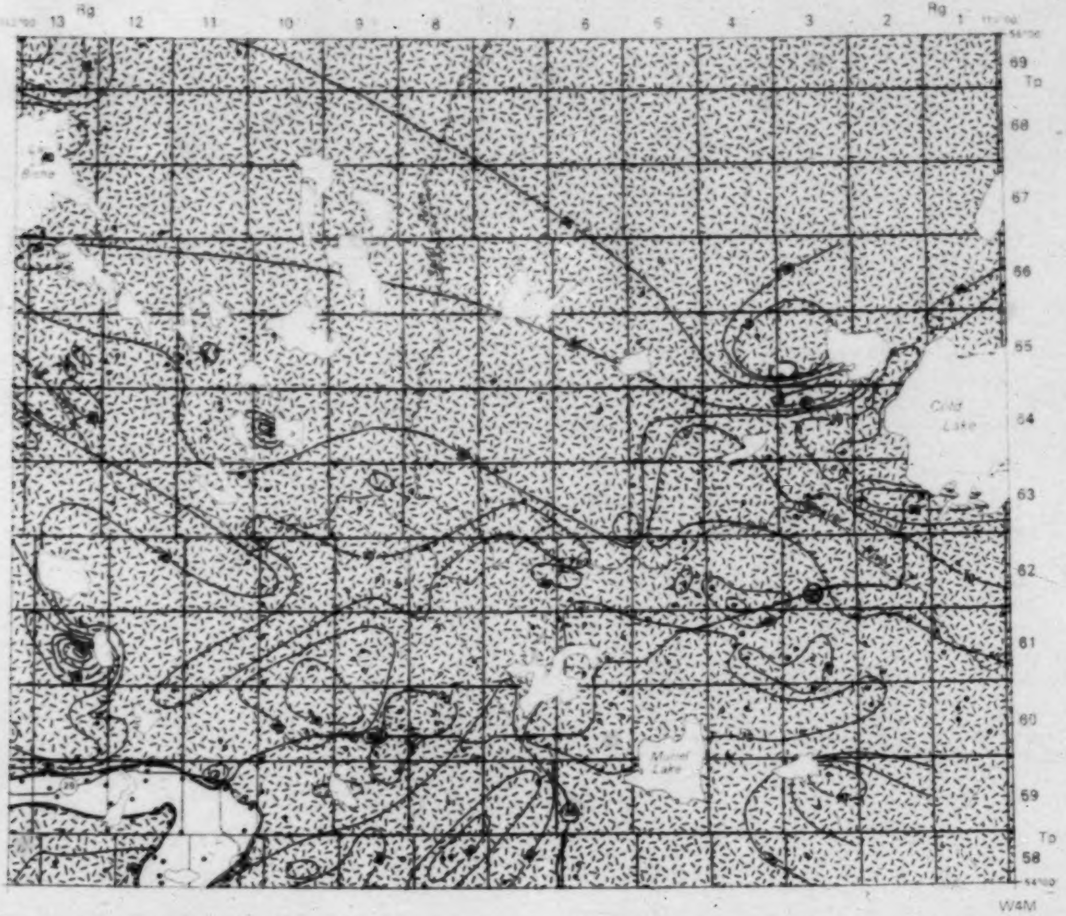

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Cold Lake
Muriel Lake
W4M

Figure: 27 Thickness of diamicton in unit 2 of the Bonnyville Formation. Note the thin to discontinuous deposits in the central part of the map area.

▨ Diamicton (till)

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - -

Isopach, Interval 10 metres .... ═ 60 ═

Data Location .... •

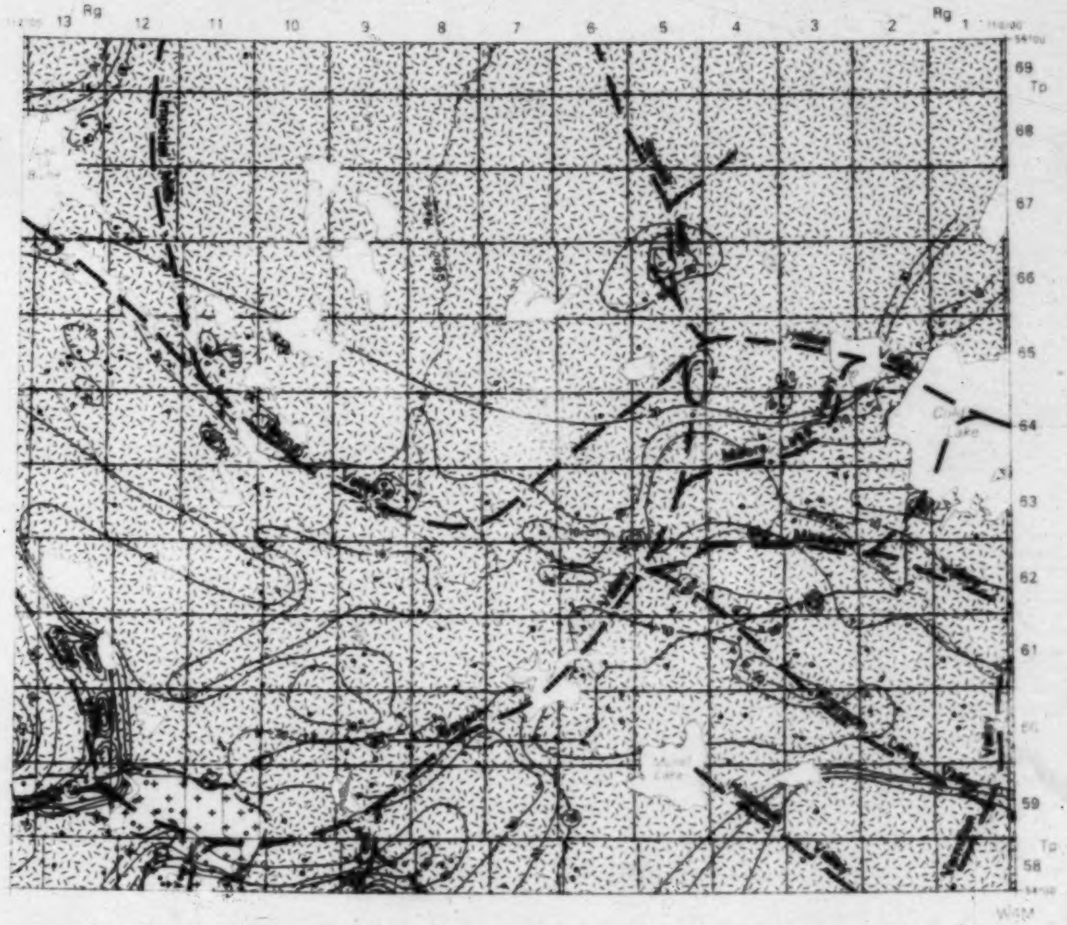

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Cold Lake
Muriel Lake
W4M

Figure:28 Total thickness of units 1 and 2 of the Bonnyville Formation.

Note the very thick deposits above the buried Kikino Valley.

▨ Unit 2: Diamicton (till)

▨ Unit 1: Diamicton (till)

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - - -

Isopach, Interval 10 metres .... ═ 10 ═

Data Location .... •

Thalweg .... ━ ━ ━

differentiated by texture alone. In the eastern part of the map area unit 2 of the Bonnyville Formation and unit 2 of the overlying Marie Creek Formation can be differentiated by their differences in carbonate and quartz content in the very coarse sand fraction: unit 2 of the Bonnyville Formation contains much less calcareous material and much more quartz than does the Marie Creek Formation (Appendix A, testholes T-6, T-16). In the central part of the map area unit 2 of the Bonnyville Formation and the Kehiwin Lake Member of the Grand Centre Formation are differentiated on the basis of significantly more very coarse sand in the matrix and more quartz in the very coarse sand fraction of unit 2 (Table 2). In the west, where unit 2 is more clayey (Figure 25), it is differentiated from other clayey diamictons, such as the Vilna Member of the Grand Centre Formation, by the relative abundance of quartz, compared to igneous and metamorphic rocks (Table 2).

Electric log responses for the Bonnyville Formation are useful in differentiating diamicton of the Bonnyville Formation from diamictons of other units. The logs generally show a distinct break in the signatures at the contact of the Bonnyville Formation with the other units. For example, over most of the east half of the map area units 1 and 2 of the Bonnyville Formation are generally less resistive than the upper part of the overlying Marie Creek Formation (Figure 5, testholes E802, E804, E1708, E1712, E1771).

Nature of Contacts

Lower Contact

In most places above the major buried valleys, unit 2 overlies either diamicton or stratified deposits of older Quaternary units. In many places on the bedrock uplands unit 2 overlies shale of the Lea Park Formation. This contact is generally sharp, though locally the amount of clay becomes increasingly greater toward the base of unit 2 (Figure 32, testhole T-9).

The contact between diamicton of unit 2 and diamicton of the Bronson Lake Formation is recognized in only one auger testhole (Figure 29, testhole T-32). The contact is well defined by the textural and compositional differences (Table 2). The buried oxidized horizon on the surface of the Bronson Lake Formation at this location suggests that the contact is also disconformable.

In those places where unit 2 overlies stratified sediment of the Muriel Lake Formation, the contact is either sharp or gradational. Resistivity logs show that in places the base of unit 2 contains numerous beds of sand and gravel which appear to grade into the coarse deposits of the underlying Muriel Lake Formation. It is uncertain if these basal beds of sand and gravel were deposited contemporaneously with the diamicton or, if they represent incorporated lenses of the underlying Muriel Lake Formation.

Upper Contact

Unit 2 of the Bonnyville Formation is overlain by either stratified sediment of the Ethel Lake and Sand River Formations (Figure 9, x-sec N1-N1'), or by diamicton of the Marie Creek and Grand Centre Formations (Figure 8, x-secs E1-E1', E3-E3'). Where unit 2 is overlain by stratified sediment the contact is sharp.

Where diamicton of the the Marie Creek Formation or the Grand Centre Formation directly overlie unit 2 of the Bonnyville Formation, the contact is considered to be disconformable on the basis of the weathered profile on the surface of unit 2. In the western part of the map area where the oxidized profile on the surface of unit 2 is more extensive, this contact is easily recognized from drill samples.

Unconformable contacts are indicated at a number of locations where the base of the overlying Marie Creek Formation is gradational with unit 2. It is believed that at these sites the top of unit 2 has been eroded and incorporated into the base of the overlying diamicton. This gradational contact is expressed in both the texture and very coarse sand composition, particularily carbonate content, of the two formations, as shown in testholes T-25, T-32, and 77SR-3 (Appendix A).

Origin

The diamictons of units 1 and 2 of the Bonnyville Formation represent tills. These tills are considered to have been deposited by the second major glaciation in the map area, herein called the Fort Kent Glaciation, rather than by a readvance of the Cherry Grove Glacier. This hypothesis is based on two lines of evidence. Firstly, the thick deposits of sand and gravel of the underlying Muriel Lake Formation indicate that an ice-free period followed the deposition of the Bronson Lake till. Secondly, the weathered profile on the surface of the Bronson Lake till, at one location, indicates a prolonged non-glacial weathering period prior to burial by the Bonnyville Formation tills.

On the basis of coarse sand composition, it is believed that the Fort Kent Glacier flowed more from the northeast than from the north. The evidence for this is twofold. Firstly, the relatively minor amounts of carbonates in both the clast and matrix fraction suggests that the Fort Kent Glacier incorporated only a small amount of the Devonian carbonates which outcrop along most of the southwest margin of the Canadian Shield in Saskatchewan and Alberta. Possibly then, the Bonnyville till is derived from that part of the Fort Kent Glacier which traversed that area northeast of the Sand River map area where the Devonian carbonates are buried by Cretaceous rocks (Whitaker and Pearson, 1972). Secondly, the relative abundance of quartz in the very coarse sand fraction and the very sandy texture of unit 2 suggests that the Fort Kent Glacier incorporated a considerable amount of quartz sand. Two sources of this sand are possible: a distant source derived from quartz sandstone of the Athabasca Formation, which outcrops along the southern edge of the Shield in northwest Saskatchewan and northeast Alberta, or, a local source derived from the extensive sand and gravel of the underlying Muriel Lake Formation in the Beaver River Lowland and Kehiwin Lake Upland Plains. The similarity throughout the map area in the composition of the very coarse sand fraction of both units 1 and 2 (Tables 4 and 5) suggests that the coarse sand, and in particular the quartz component, was derived from a distant source, possibly the Athabasca Formation, and not locally.

The clayey till of unit 1 is believed to result from the erosion and incorporation of shale and siltstone as the Fort Kent Glacier advanced over the exposed bedrock uplands in the map area. Water-well driller's records in the area south of Spedden in Tp 59, Rg 13, describe the unit as consisting of clay with very few pebbles, and in places resembling shale. Directly north, in the segment of the Kikino Valley in Tps 59-60, Rg 13, till of unit 1 is absent; instead, a very thick sequence of shale, siltstone, sandstone, coal and preglacial gravel has been displaced and incorporated as an ice-thrust glacial erratic, to form the base of the Bonnyville Formation (Figure 9, x-sec E4-E4', testhole R81SR-1). This sequence of stratified sediments represents a slab of the Belly River Formation which was glacially displaced and deposited relatively intact within the valley. Near Spedden however, it is believed that the process of glacial comminution reworked the bedrock sufficiently to produce the very clayey till of unit 1. A similar sequence of glacially-displaced sediment was recognized by Gold (1978) who mapped thick masses of the Belly River Formation in parts of the Beverly Valley directly southwest of the Kikino Valley in the Tawatinaw map area.

Tables 4 and 5 show that the within hole variations in both texture and sand composition of the tills of units 1 and 2 are generally small, varying not more than 5% from the mean, and commonly less than 3%. The between hole variations on the other hand, especially for the textural properties, are larger, though generally are still smaller than the variations between other formations (Table 2). As an example, in the eastern two-thirds of the map area the texture of unit 2 varies by as much as 10%, but it is still the sandiest diamicton and can be correlated by texture alone.

There are however some variations in the properties of the Bonnyville Formation, particularily unit 2, which are of interest and warrant discussion. The most striking variation is the relatively abrupt change in texture of unit 2, from a sandy till in the eastern two-thirds of the map area to a more clayey till in the west. This change is recognized across a north-south line which runs essentially along the west edge of Rg 10 (Figure 25). Furthermore, the sandy eastern facies apparently overlies the clayey facies along this trend, as shown in testholes 77SR-2, 77SR-21, and 77SR-28 (Appendix A). Presumably, this transition from a sandy till to a clayey till reflects a change in the underlying source material from which the till of unit 2 was derived. In the eastern and central parts of the map area the Bonnyville Formation overlies widespread sand and gravel of the Muriel Lake Formation, and glacial incorporation of this coarse sediment may contribute to the sandy texture of unit 2 in that area. In the west on the other hand, the Muriel Lake Formation is not nearly as widespread. Rather, a considerable extent of exposed shale and siltstone directly underlies the Bonnyville Formation. It is likely that incorporation of this finer sediment accounts for the less sandy and more clayey texture of both units 1 and 2 in the west. Possibly the clayey facies of unit 2 may also represent a gradational contact with the underlying clayey unit 1.

To some degree the above interpretation, that local incorporation of the underlying material altered the textural properties of unit 2, is contradicted by the fact that the composition of the very coarse sand fraction of both the sandy and clayey facies of unit 2 is similar. This suggests that at least the source of the coarse sand component was the same for both units, and therefore not locally derived. It is possible that glacial erosion and incorporation of the locally underlying bedrock enriched only the finer silt-clay fraction of the matrix of unit 2 from east to west, without affecting the lithic composition of the very coarse sand fraction.

Variations are also present in the lithic composition of unit 2 of the Bonnyville Formation. The data from some testholes show a decrease with depth in the amount of quartz and an increase in the amount of limestone in the very coarse sand fraction (Appendix A, testholes T-12, T-18, T-43, and 77SR-21). Testholes T-12, T-18, and T-43 all lie in the same physiographic setting, the Beaver River Lowland Plain, and in this area unit 2 overlies stratified sediment of the Muriel Lake Formation. Possibly the compositional variation of unit 2 in these testholes reflects a change in the clast composition of the underlying Muriel Lake Formation. Data from the Muriel Lake Formation is not available to verify this however.

It is uncertain if the tills of units 1 and 2 of the Bonnyville Formation were deposited by two different advances of the Fort Kent Glacier, or if they reflect textural variations of a single till sheet, deposited by one glacial advance. Certainly, along the Helina Valley in the north, and along the Beverly Valley in the southwest, two advances are suggested, as evidenced by the extensive and thick sequence of stratified sediment which separates the tills of units 1 and 2 (Figure 8 and 9, x-secs E2-E2', and E4-E4'). As well, in many places the resistivity responses show a sharp, nongradational contact between the tills of units 1 and 2. Although this sharp contact suggests a depositional break, which implies perhaps two separate glacial advances, sharp textural contacts have been noted within a single till unit which is defined by its lithic composition (see chapter X).

In contrast to the above, in the southwest the clayey till of unit 1 can be considered to be a textural facies of a single till sheet of the Bonnyville Formation. The evidence for this is that north of Spedden in Tps 59-60, Rgs 12-13, the contact between units 1 and 2 is variable, in places sharp, in other places gradational. This variable contact likely reflects the differences in the amount of the underlying Lea Park and Belly River Formations, which have been glacially eroded and incorporated by the Fort Kent Glacier. In places the displaced masses of bedrock have remained relatively intact at the base of the formation, and thus form sharp contacts with the till. In other places these blocks are broken up and comminuted so as to form a very clayey basal till which has a gradational contact with the less clayey upper till.

Glacial margins of the Fort Kent Glacier are indicated in two regions of the map area where the Bonnyville Formation is especially thick. In the first region, the Marguerite Lake and Medley River Uplands, it appears that the glacier remained stable long enough to deposit as much as 50 m of sediment (Figure 28). This thick cover of the Bonnyville Formation forms much of the core, and serves to accentuate the scarp along the southern flank of these uplands. Another ice-margin is suggested by a high relief, linear ridge in Tp 58, Rgs 8-11 in the southwest. Similarily, more than 50 m of sediment are interpreted to have been deposited along a glacier margin (Figure 28).

The presence of a poorly developed and preserved oxidized profile on the surface of the Bonnyville till in the east (Appendix A, testhole T41), and a well developed, extensive profile in the west (Appendix A, testholes 77SR-11, 77SR-15, 77SR-21) is offerred as evidence that the Bonnyville Formation was exposed and weathered during the nonglacial period which followed.

VIII. ETHEL LAKE FORMATION

Source of name: Ethel Lake, located in Tp 64 Rg 3 W4M in the Sand River map area, NTS 73L.

Type section: Alberta Geological Survey auger testhole T-32, located in LSD 12 Sec 1 Tp 64 Rg 3 W4M in the northeast part of the Sand River map area, NTS 73L (Figure 29).

Type area(s): The area around Ethel Lake within the Beaver River Lowland Plain in the east central part of the Sand River map area, NTS 73L; the area around Reita Lake within the Reita Lake Uplands in the southeast corner of the Sand River map area, NTS 73L.

Reference Sections: Alberta Geological Survey auger testholes T-5 (LSD 2 Sec 16 Tp 59 Rg 3 W4M), T-13B (LSD 1 Sec 30 Tp 60 Rg 2 W4M), T-15 (LSD 16 Sec 20 Tp 60 Rg 1 W4M); Alberta Environment testholes E1708 (LSD 4 Sec 14 Tp 62 Rg 5 W4M), E1937 (LSD 12 Sec 33 Tp 60 Rg 3 W4M), E1948 (LSD 4 Sec 17 Tp 60 Rg 3 W4M).

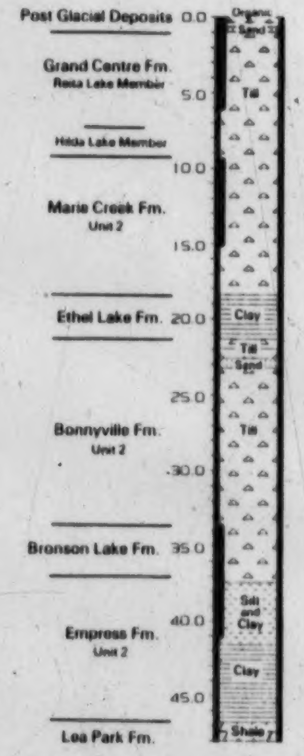
A. Description of Unit

The Ethel Lake Formation consists of stratified sediment composed mainly of silt and clay, with lesser amounts of sand and gravelly sand. The formation is recognized with certainty only in those places where it overlies the Bonnyville Formation and in turn is overlain by the Marie Creek Formation. The formation does not outcrop in the map area, but is recognized from dry-auger flite samples, rotary drill cuttings and geophysical logs, primarily electric logs.

Silt and clay of the formation are typically unoxidized grey (5Y 4/ 1). Oxidized horizons are not recognized within or at the surface of the formation at any of the testhole locations. Distorted partings and laminations of silt and clay layers in the dry-auger samples indicate bedding within the unit. The silt partings react mildly to the application of 10% HCL acid in field tests. The silt and clay have a moisture content which ranges between 14% and 20%, and typically they are soft and easy to penetrate with a dry-auger.

Coarser sand and gravel comprise a minor amount of the Ethel Lake Formation although their extent is widespread. The sand varies from fine to coarse grained and is

T32



Alberta Geological Survey Testhole T 32
Location SW of LSD 12 Sec 1 Twp 64 Rng 3 W of 4 Mer . NTS 73L
Elevation 1800 Ft 549 M Source 1 50,000 NTS 73L/9
Date drilled 197608 06 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	37.0	26.0	37.0	40.0	29.0	31.0	1.86	13.3	21.4	8.9	0.24	69.6	24.4	1.2	2.3	3.8	0.0	0.0	266
2.00	36.0	25.0	38.0	40.0	28.0	33.0	1.83	15.4	29.1	12.2	0.37	65.5	28.5	0.8	2.4	2.8	0.4	0.0	249
3.00	36.0	25.0	39.0	40.0	28.0	32.0	2.00	15.6	26.2	10.9	0.24	65.6	27.8	0.7	2.6	2.2	0.4	0.0	270
4.00	37.0	26.0	37.0	41.0	28.0	31.0	1.68	14.6	25.8	10.8	0.30	64.0	27.2	2.9	1.3	4.2	1.2	0.0	239
5.00	34.0	26.0	41.0	37.0	28.0	35.0	2.99	14.5	27.6	11.6	0.28	63.9	27.0	1.3	3.5	4.4	0.4	0.0	230
6.00	32.0	26.0	42.0	35.0	29.0	35.0	1.85	14.2	26.3	11.0	0.21	64.4	26.6	2.2	2.6	4.3	0.0	0.0	233
7.00	33.0	28.0	39.0	36.0	31.0	33.0	1.65	12.3				69.3	19.1	2.7	3.1	5.3	0.8	0.0	225
8.00	26.0	28.0	46.0	30.0	31.0	39.0	1.14	14.1	25.3	10.6	0.24	69.4	22.0	0.0	4.1	4.6	0.0	0.0	173
9.00	20.0	31.0	49.0	24.0	36.0	41.0	0.72	14.1	28.2	11.8	0.25	58.8	29.8	0.0	2.6	8.8	0.9	0.0	114
10.00	38.0	30.0	31.0	42.0	32.0	26.0	2.37	8.3	43.6	18.2	0.21	67.1	16.4	0.3	3.4	10.6	1.6	0.0	161
11.00	40.0	30.0	31.0	43.0	31.0	26.0	2.54		41.3	17.2	0.19	66.3	15.6	0.6	2.8	13.4	1.2	0.0	320
12.00	40.0	28.0	31.0	45.0	29.0	26.0	2.35	10.0	43.7	18.2	0.16	65.9	19.6	0.3	2.4	10.1	2.0	0.0	296
13.00	41.0	28.0	32.0	44.0	31.0	25.0	2.43	8.2	38.6	16.1	0.15	63.1	19.6	2.0	5.1	8.7	1.9	0.0	312
14.00	46.0	27.0	27.0	50.0	29.0	22.0	2.48	8.7				61.4	23.5	1.2	4.0	7.1	2.4	0.0	324
15.00	51.0	27.0	21.0	56.0	27.0	17.0	3.64	7.1	29.3	12.2	0.25	58.7	30.4	1.1	3.4	5.0	1.0	0.0	477
16.00	55.0	23.0	22.0	58.0	24.0	18.0	3.06	6.6	30.1	12.6	0.28	56.7	32.0	0.2	4.6	4.8	1.6	0.0	413
17.00	56.0	23.0	22.0	60.0	23.0	18.0	2.76	7.2	30.7	12.8	0.23	55.5	34.7	0.5	3.7	3.7	2.1	0.0	404
18.00	46.0	27.0	28.0	49.0	30.0	21.0	2.56	7.8	29.1	12.2	0.26	59.2	30.9	0.3	2.1	4.5	3.0	0.0	333
19.00								19.8											
20.00								18.6											
21.00	31.0	25.0	44.0	34.0	34.0	32.0	1.18	15.6	15.5	6.5	0.42	49.0	45.0	3.3	0.7	1.3	0.7	0.0	151
22.00	40.0	25.0	35.0	42.0	35.0	23.0	2.71	11.5				54.4	39.7	2.0	2.6	0.0	1.4	0.0	388
23.00	52.0	30.0	18.0	56.0	33.0	11.0	3.16	8.7	20.5	8.6	0.35	59.1	34.5	1.8	3.0	0.5	1.4	0.0	438
24.00	53.0	28.0	19.0	56.0	30.0	14.0	3.44	8.9				53.4	40.5	1.0	1.9	1.5	1.6	0.0	474
25.00	52.0	29.0	19.0	56.0	31.0	14.0	3.37	8.7	20.7	8.7	0.30	58.4	35.8	0.9	1.3	0.9	2.6	0.0	450
26.00	53.0	29.0	18.0	57.0	30.0	14.0	3.36	8.5				60.7	33.5	1.2	2.1	0.7	1.9	0.0	427
27.00	53.0	28.0	19.0	57.0	30.0	14.0	3.29	8.0	20.5	8.6	0.33	60.1	34.6	0.2	3.0	1.6	0.4	0.0	436
28.00	54.0	26.0	20.0	58.0	28.0	14.0	3.36	8.3				58.7	34.3	1.6	2.0	2.0	1.1	0.0	443
29.00	53.0	26.0	21.0	57.0	27.0	16.0	3.41	8.1	20.0	8.4	0.25	56.0	38.0	0.4	1.9	1.0	2.5	0.0	484
30.00	53.0	26.0	22.0	56.0	28.0	16.0	3.61	9.1				60.5	33.5	1.4	1.9	1.7	1.0	0.0	483
31.00	54.0	25.0	21.0	58.0	27.0	15.0	4.64	10.3	19.0	7.9	0.27	56.2	35.5	1.2	2.7	1.5	2.8	0.0	598
32.00	53.0	25.0	22.0	56.0	27.0	17.0	3.75	7.8				54.1	38.4	1.4	3.2	1.6	1.4	0.0	497
33.50	23.0	34.0	43.0	28.0	35.0	38.0	0.74	12.1	20.4	8.6	0.36	38.3	45.2	2.6	4.4	1.7	7.8	0.0	115
34.00	24.0	34.0	43.0	28.0	35.0	37.0	0.80	13.3				57.5	28.3	0.0	5.0	3.3	5.8	0.0	120
35.00	23.0	34.0	43.0	28.0	35.0	37.0	0.80	13.7	21.4	9.0	0.31	57.5	28.3	0.0	5.0	3.3	5.8	0.0	120
36.50	24.0	31.0	45.0	28.0	33.0	39.0	0.76	12.0				34.3	44.4	0.0	3.7	5.6	12.1	0.0	108
37.00	6.0	41.0	53.0	8.0	48.0	44.0	0.14	16.6				21.4	17.9	0.0	0.0	3.6	57.1	0.0	28
38.00								18.7											
39.50								16.0											
40.00								18.4											
41.00								14.9											
42.50								16.3											
43.00								17.5											
44.00								15.7											
45.00								18.2											
46.00								20.4											
47.00								19.5											

NOTE:
Heavy Bar Denotes Oxidized Profile

Figure:29 Type section of the Ethel Lake Formation, Alberta Geological Survey testhole T 32 (LSD 12 Sec 1 Tp 64 Rg 3 W4M).

generally well sorted. The composition of the clasts was not examined in detail but described in the field as typical glacial sand and gravel, with clasts derived from the Shield as well as the local bedrock. In much of the southwest part of the map area the sand and gravel is interbedded with finer silt and clay.

Distribution, Thickness, and Subcrop Topography

The Ethel Lake Formation is widespread, but not continuous, throughout most of central and southeastern part of the map area (Figure 30). It is not recognized in the uplands to the north or southwest. The distribution of the formation in the Beaver River Lowland Plain is characterized by a number of large "windows" in which the unit is absent (Figure 30). The elevation of the top of the formation ranges from as high as 615 m in Tp 58, Rg 3 along the southern edge of the map area, to as low as 510 m along the Beaver River in the east.

Silt and clay of the Ethel Lake Formation are both extensive and thick (Figures 30 and 31). These fine deposits form a broad arc which extends from the Lac LaBiche area in Tp 67, Rg 12, southeastward to the Reita Lake area in Tp 59, Rg 3. Near Reita Lake the formation lies at an elevation as high as 615 m and is as much as 20 m thick (Figure 8, x-sec E1-E1', and Figure 31). From here, the top of the formation decreases in elevation northward toward the Beaver River Lowland Plain, where the deposits are generally less than 5 m thick. Similarily, in the south-central and southwest parts of the map area the top of the formation lies at an elevation of about 600 m but decreases in elevation northeastward toward the central part of the map area.

Along the western part of the formation, silt and clay are either overlain by sand and gravel or are interbedded with sand and gravel (Figure 30). This sequence of interbedded clay, silt, sand and gravel forms a number of relatively thick deposits which extend from Tp 59, Rg 7 in the Kehiwin Uplands northwestward into Tp 65, Rg 12, in the Lac LaBiche Uplands (Figure 31).

Above segments of the buried Helina and Beverly valleys, in the central part of the map area the Ethel Lake Formation is characterized by a thin sand and gravel veneer (Figure 31). Although this coarse sediment is considered to be widespread, the data are not sufficient to be certain that the distribution is as continuous as shown in Figure 30.

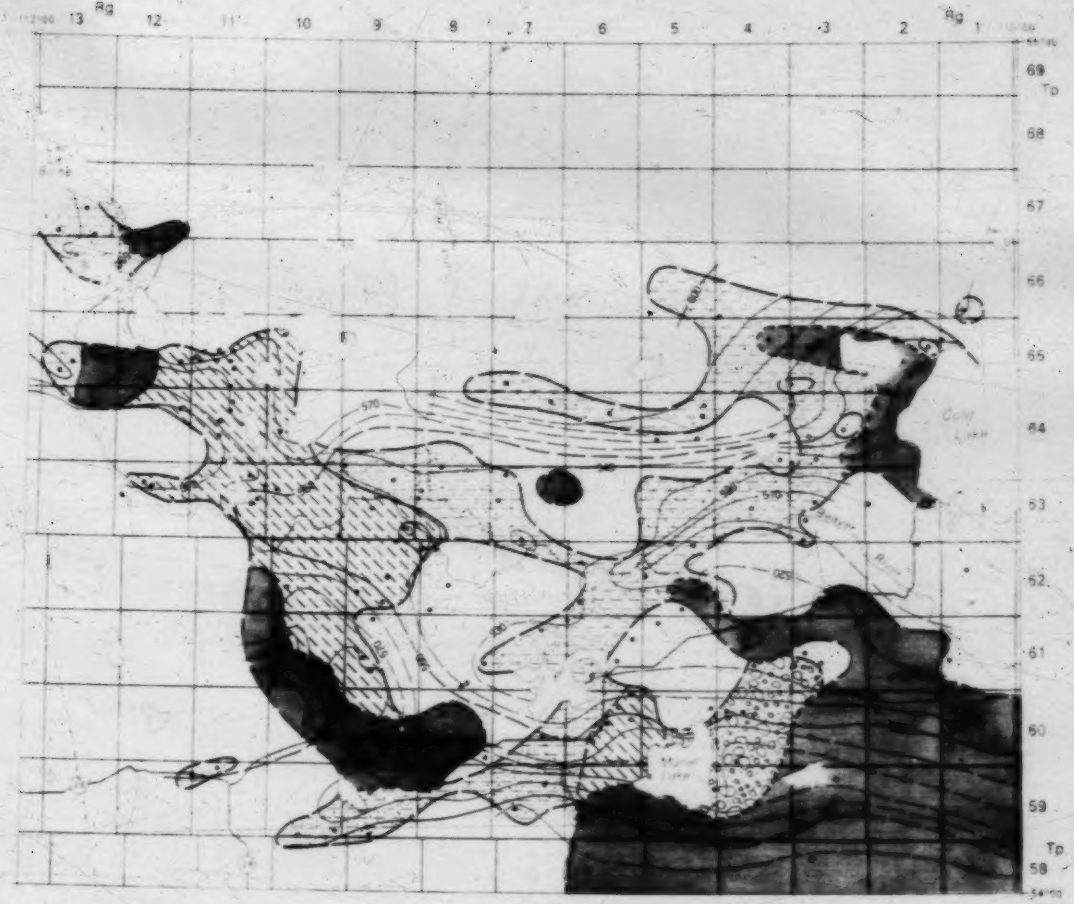

Rg
13
12
11
10
9
8
7
6
5
4
3
2
1
69
Tp
68
67
66
65
64
63
62
61
60
59
58
570
510
520
550
530
Cold Lake

Figure: 30 Elevation of the upper surface of the Ethel Lake Formation.

Note the sporadic distribution of the formation in the east-central part of the map area.

- ■ Silt and Clay
- ⬚ Sand and Silt
- ▨ Sand and Gravel
- ▨ Clay, Silt, Sand and Gravel

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -
Contours, Interval 10 metres:
Defined 500
Approximate 500
Data Location .... •

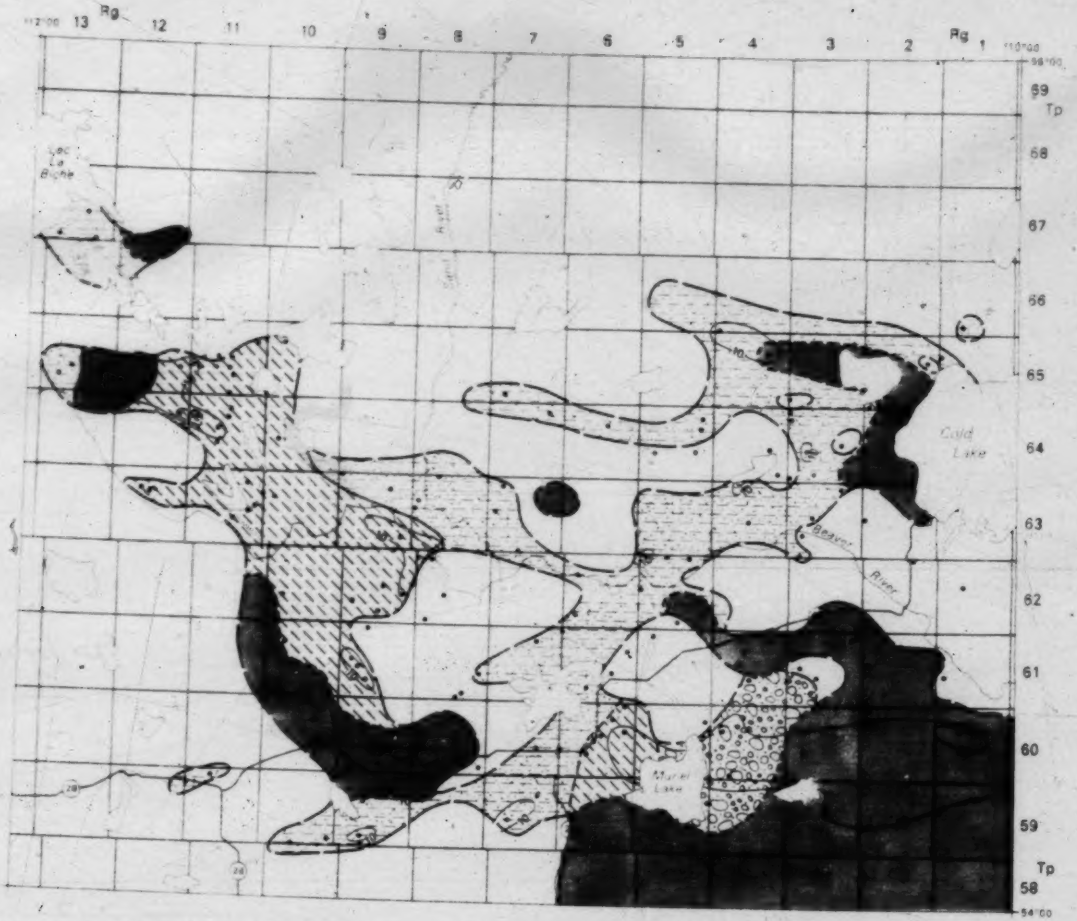

112°00
Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
Lac La Biche
Cold Lake
Beaver River
Muriel Lake
10
28
W4M

Figure: 31 Thickness of clay, silt, sand and gravel in the Ethel Lake Formation.

Note the predominance of relatively thick deposits of silt and clay along the southern and south-western boundary of the formation.

■ Silt and Clay

▤ Sand and Silt

▨ Sand and Gravel

▧ Clay, Silt, Sand and Gravel

Unit Boundaries:
Approximate
Assumed
Isopach, Interval 10 metres
Data Location

Differentiation from other Formations

The Ethel Lake Formation is differentiated from all other stratified units primarily by stratigraphic position. It can be recognized with certainty only in those areas where it overlies glacial sediment (till) of the Bonnyville Formation and where it in turn is overlain by glacial sediment (till) of the Marie Creek Formation. Thus, in the southwest corner of the map area, where the overlying Marie Creek Formation is absent, the Ethel Lake Formation is difficult to differentiate from stratified deposits of the the Sand River Formation (Figure 9, x-secs E4-E4′ and N1-N1′). This problem is resolved by assuming that all stratified deposits, which overlie the the Bonnyville Formation and which are overlain by the Grand Center Formation, are stratigraphically as young as possible, and are therefore included within the Sand River Formation. This means that in the southwest, some of the sediment included within the Sand River Formation could have been deposited much earlier, contemporaneously with the Ethel Lake Formation, but cannot be differentiated.

Nature of Contacts

Lower Contact

In places, and particularily within the uplands in the southeast, silt and clay of the Ethel Lake Formation rest on an oxidized surface of the Bonnyville Formation, indicating a disconformable contact (Figure 8, x-sec E1-E1′, testhole T-41). In most places this contact is sharp and nongradational. One exception is in testhole T-5 (Figure 8, x-sec E1-E1′, and Appendix A), which is located on the north facing slope of the Reita Lake Upland. Here, a thin layer of till of the underlying unit 2 of the Bonnyville Formation lies within the base of the Ethel Lake Formation. It is likely that this layer of tills represents glacially displaced material which has been thrust into the Ethel Lake Formation.

Within the Kehiwin Upland Plain and the Beaver River Lowland Plain in the central part of the map area, sand and gravel of the Ethel Lake Formation overlie unoxidized till of the Bonnyville Formation. These deposits are considered to lie conformably on the surface of the Bonnyville Formation.

Upper Contact

The upper contact of silt and clay of the Ethel Lake Formation is commonly gradational with the base of the Marie Creek Formation, and is considered to be conformable. This gradational contact reflects glacial erosion and incorporation of the top of the Ethel Lake Formation into the base of the Marie Creek Formation (Appendix A, testholes T-13B, T-15).

The coarser sand and gravel of the Ethel Lake Formation generally have a much sharper contact with the base of the Marie Creek Formation diamicton. It is uncertain however if this contact is conformable or disconformable.

Origin

Silt and clay of the Ethel Lake Formation are interpreted to have a glaciolacustrine origin, deposited from proglacial lakes which formed during the advance of the third major glaciation in the map area, herein named the Ardmore Glaciation. The evidence for a glaciolacustrine origin, rather than a glaciofluvial origin, for example, is the following. Firstly, the dry-auger samples show that the silt and clay are almost always finely-bedded, with rhythmic beds visible in places. As well, these sequences of finely-bedded deposits are generally thick, locally exceeding 5 metres in thickness, which suggests prolonged periods of still water, such as might be found in a lacustrine environment. Furthermore, depositional breaks, marking changes in the sedimentational regimes which might be expected to be more common in a fluctuating fluvial environment, are not recorded in the auger samples. Finally, these fine deposits are very extensive and continuous throughout the east part of the map area, suggesting deposition in a large, expansive lake. In fact, in the southeast these fine deposits drape the tops of the uplands as well as the flanks and lowlands, and are not confined to valleys or channels, as would be expected for fluvial deposits. All of these lines of evidence favor a glaciolacustrine, rather than a glaciofluvial origin.

The evidence that the Ethel Lake Formation was deposited along an ice-margin of the advancing Ardmore Glacier, rather than along a margin of the retreating Fort Kent Glacier is based on the fact that in none of the testholes was an oxidized profile recognized of the surface of the formation. This indicates that the Ethel Lake Formation was buried by till very soon after it was deposited. Thus, its surface could not be weathered. One argument which can be offered to counter this hypothesis is the following. In fact, the Ethel Lake Formation was deposited during the retreat of the Fort Kent Glacier, and was oxidized during the nonglacial which followed. This profile was later eroded by the Ardmore Glacier. However, as is discussed in the following chapter, even though discrete "clasts" of silt and clay are recognized within the till which was deposited by the Ardmore Glacier (that is, the Marie Creek Formation), in no cases were these "clasts" oxidized, which suggests that the surface of the Ethel Lake Formation was not weathered.

It is believed that most of the sediment deposited within these proglacial lakes was derived from both meltwater flowing from the Ardmore Glacier, and from natural drainage ponded against the glacier. The curvilinear configuration of the distribution of the thick deposits of the Ethel Lake Formation in the south and southwest shows ~~the~~ control that the glacier had on the distribution of these proglacial lakes (Figure 30). Though not conclusive, the predominance of thick deposits of the Ethel Lake Formation along this northwest-southeast curvilinear trend suggest that the Ardmore Glacier margin remained stable in that position for an extended period of time.

The distribution of the lithologically different deposits of the Ethel Lake Formation likely reflects the difference in distance from source. For example, east of Reita Lake in the southeast corner of the map area the formation consists almost entirely of silt and clay, with only a minor amount of sand or gravel. The predominance of this fine sediment suggests that the source of meltwater was further to the north, when the glacier was more distant. As this margin advanced southwest, the lakes migrated accordingly, rising up the regional north facing slope of the Reita Lake Upland, and ultimately depositing silt and clay at an elevation at least 90 m higher than those deposits within the Beaver River Lowland Plain. Farther west, along the southwest margin of the Ethel Lake Formation, the presence of sand and gravel interbedded with, or overlying the silt and clay (Figure 9, x-sec N1-N1', testholes E966 and E1723), indicates that glaciofluvial sediment is also present, suggesting a source nearer to the glacier margin. Possibly these sediments were deposited in an ice-contact delta along the northeast margin of the ice-ponded proglacial lakes.

Based on geographic distribution, the veneer of sand and gravel in the north end of the Kehiwin Upland Plain and the Beaver River Lowland Plain, is believed to have a glaciofluvial origin, possibly deposited during the retreat of the Fort Kent Glacier, rather than the advance of the Ardmore Glacier. Figures 26 and 30 show that these coarser grained deposits lie within a poorly developed drainage system which developed after the Bonnyville Formation was deposited. The underlying Bonnyville Formation is relatively thin along this drainage system, indicating that it was eroded presumably by the same meltwater which deposited this sand and gravel.

IX. MARIE CREEK FORMATION

Source of name: Marie Creek, Alberta located in the east part of the Sand River map area, NTS 73L.

Type Section: Alberta Geological Survey auger testhole T-9, located along the Beaver River in LSD 13, Sec 10, Tp 62, Rg 2, W4M within the Sand River map area NTS 73L (Figure 32).

Type Area: The area northwest of the town of Grand Centre in the east part of the Sand River map area, NTS 73L.

Reference Sections: Outcrops LA81-1, (LSD 16, Sec 19, Tp 63, Rg 2, W4M), and SRA-200, (LSD 11, Sec 1, Tp 63, Rg 3, W4M) located along the Marie Creek; Alberta Geological Survey auger testholes T-6 (LSD 16, Sec 31, Tp 62, Rg 3, W4M), T-13B (LSD 1, Sec 30, Tp 60, Rg 2, W4M), and T-32 (LSD 12, Sec 1, Tp 64, Rg 3, W4M); Alberta Environment testholes E802 (LSD 5 Sec 32 Tp 61 Rg 5 W4M), E1712 (LSD 1 Sec 11 Tp 62 Rg 5).

A. Description of Formation

The Marie Creek Formation consists of diamicton which is characterized by: a high amount of calcareous material, particularily dolomite and dolostone, in both the very coarse sand and silt-clay fractions, a high amount of very coarse sand in the matrix texture, and a high resistivity response. Commonly, the upper part of the formation, both in outcrop and subsurface, is strongly oxidized.

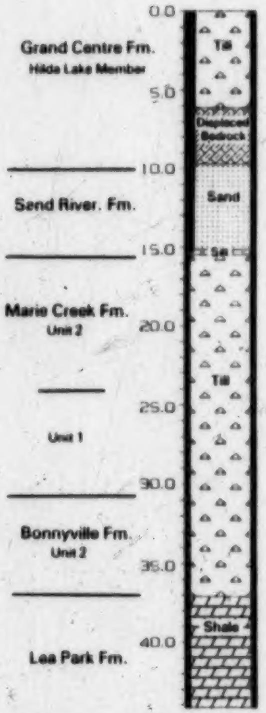
The Marie Creek Formation is extensive, but does not cover all of the Sand River map area. Only the upper parts of the formation outcrop, mainly along stream cuts and shallow man made exposures such as road cuts. The entire formation has been mapped in the subsurface from dry-auger flite samples, rotary drill cutings, sidewall samples, and geophysical logs.

On the basis of matrix texture, the Marie Creek Formation is divided into two units; a clayey diamicton, unit 1, which is overlain by a sandy diamicton, unit 2.

T9

Alberta Geological Survey Testhole T 9
Location SE of LSD 13 Sec 10 Twp 62 Rng 2 W of 4 Mer . NTS 73L
Elevation 1775 Ft 541 M Source 1 50,000 NTS 73L/8
Date drilled 197607 08 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00	9.0	19.0	73.0	10.0	26.0	64.0	0.41	20.0				68.4	21.1	0.0	0.0	0.0	10.6	0.0	57
3.00	26.0	29.0	46.0	29.0	33.0	39.0	1.15	12.6				77.5	15.2	0.7	2.0	3.3	1.3	0.0	151
5.00	28.0	27.0	45.0	32.0	30.0	38.0	1.43	12.6				64.7	29.4	0.5	1.6	2.1	1.6	0.0	187
6.00	4.0	41.0	54.0	5.0	51.0	44.0	0.12	15.2											
8.00	2.0	48.0	50.0	3.0	57.0	41.0	0.21	14.6											
9.00	4.0	34.0	62.0	5.0	45.0	50.0	0.27	15.6											
17.00	40.0	33.0	27.0	45.0	33.0	22.0	3.12	8.9				57.3	18.7	0.3	3.8	13.6	4.1	0.0	396
18.00	42.0	31.0	28.0	46.0	32.0	22.0	2.62	8.7				59.2	20.7	1.2	2.7	15.6	6.0	0.0	328
20.00	39.0	33.0	28.0	43.0	34.0	23.0	2.80	8.9				64.9	16.4	0.0	2.7	14.3	1.7	0.0	365
22.00	46.0	26.0	28.0	50.0	28.0	22.0	2.81	9.6				61.1	26.8	0.9	1.5	8.2	1.5	0.0	329
23.00	41.0	26.0	33.0	44.0	29.0	27.0	3.53	9.1				74.4	18.4	0.4	1.5	3.7	1.5	0.0	457
24.00	35.0	31.0	34.0	38.0	35.0	27.0	2.20	9.8				68.3	26.0	0.3	2.0	3.3	0.0	0.0	300
26.00	32.0	34.0	34.0	36.0	37.0	27.0	2.20	9.6				64.0	24.7	1.7	3.1	4.5	2.0	0.0	292
27.00	32.0	33.0	35.0	35.0	36.0	28.0	2.18	9.8				66.2	25.4	0.0	3.8	3.5	1.1	0.0	287
28.00	28.0	32.0	40.0	31.0	38.0	32.0	2.03	11.0				62.5	27.6	0.4	3.9	3.9	1.8	0.0	283
31.00	48.0	29.0	24.0	51.0	31.0	18.0	3.05	9.3				63.4	26.8	0.0	2.3	5.7	1.8	0.0	385
32.00	48.0	29.0	23.0	52.0	31.0	18.0	3.01	8.6				58.4	29.1	1.0	4.8	4.6	1.9	0.0	413
33.00	42.0	28.0	30.0	46.0	30.0	25.0	2.43	8.6				60.8	27.5	1.9	4.9	0.6	4.0	0.0	324
34.00	40.0	30.0	30.0	44.0	31.0	25.0	2.66	10.2				53.0	33.9	2.6	6.6	1.7	2.3	0.0	351
35.00	42.0	27.0	31.0	46.0	29.0	25.0	3.00	8.2				61.3	30.3	2.1	2.6	2.1	1.8	0.0	390
36.00	39.0	30.0	32.0	43.0	31.0	26.0	2.80	10.1				57.8	32.5	0.5	6.1	1.9	1.3	0.0	379
40.00								14.9											
42.00								14.8											
44.00																			



NOTE:
Heavy Bar Denotes Oxidized Profile

Figure: 32 Type section of the Marie Creek Formation and Sand River Formation. Alberta Geological Survey testhole T 9 (LSD 13 Sec 10 Tp 62 Rg 2 W4M).

B. Unit 1

Description of unit

Unit 1 of the Marie Creek Formation has been mapped from auger testhole samples and electric logs responses only. It consists of unoxidized, dark grey (5Y 4/1) sandy-clay diamicton. The average matrix texture of the unit is about 32% sand, 30% silt, 38% clay, with 2.0% very coarse sand (Table 2). The textural variations range between 26% to 37% sand, 25% to 35% silt, and 26% to 37% clay (Table 6). In many dry-auger flite samples discrete lenses or attenuated "clasts" of silt and clay are found, confined to thin layers or streaks within the diamicton. In many places these streaks of silt and clay are imbedded in a more sandy matrix, similar to that of the above unit 2 of the Marie Creek Formation. The silt and clay layers contribute to a moisture content of about 11%, slightly higher than that of the overlying unit 2.

The composition of the very coarse sand fraction averages about 62% igneous and metamorphic fragments, 27% quartz fragments, 3% limestone, 6% dolostone, less than 1% quartzite and quartz sandstone fragments, and less than 2% local rock fragments (Table 2). The variations range between 56% to 66% igneous and metamorphic rock fragments, 22% to 32% quartz fragments, 2% to 7% limestone fragments, 2% to 9% dolostone fragments, less than 2% quartz sandstone and quartzite fragments, and 1% to 2% local rock fragments (Table 6).

Calcareous material makes up 12% to 17% of the silt-clay fraction, with dolomite more abundant than calcite (calcite/dolomite ratio = .25, Table 2).

The clay mineralogy of a few representative samples of unit 1 consists of about 45% to 55% illite, 25% kaolinite, 13% to 24% montmorillonite, and 7% chlorite (Appendix B).

Distribution, Thickness and Subcrop Topography

Unit 1 of the Marie Creek Formation is confined primarily to the Beaver River Lowland Plain and the Reita Lake Upland (Figure 33). The unit extends in a lobe form southwest as far as Tp 59, Rg 10, following a shallow depression on the surface of the underlying Ethel Lake Formation (Figure 30). A number of smaller deposits of unit 1 have

Table 6. Properties of unit 1 of the Marie Creek Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy												Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dst. %		Qtzite & Qtz. Sst. %		Local %		CO_2 %		Calcite Dolomite %	
			X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.
T3	6-36-61-1-W4M	15	34	3	38	2	2.4	5	13	6	48	4	32	4	7	2	4	1	4	4	.9	2				
T5	2-16-59-3-W4M	12	32	2	35	1	2.2	6	11	1	64	2	22	3	3	1	9	1	8	8	1.3	5	17	1	18	04
T6	15-31-62-3-W4M	8	28	4	49	6	1.5	3	13	1	64	5	27	4	3	1	4	2	9	8	2.3	2	12	.2	21	06
T9	13-10-62-2-W4M	4	32	3	36	3	2.2	.1	10	6	65	2	29	1	3	1	4	1	6	8	1.6	5				
T12	4-4-62-4-W4M	2	27	1	38	1	1.2	-	13	-	60	1	33	1	2	-	4	1	2	2	1.2	5				
T13B	1-30-60-2-W4M	4	27	3	38	-	1.3	4	11	.3	63	4	24	4	5	7	6	4	5	5	2.0	.9				
T14	4-17-60-3-W4M	2	21	-	39	-	1.3	1	11	2	59	2	30	3	6	-	8	3	5	3	3	.4				
T15	16-20-60-1-W4M	6	34	1	33	1	2.0	4	11	6	60	1	24	2	2	1	7	2	4	-	1.1	6				
T16	4-30-61-1-W4M	2	29	1	36	1	2.0	1	13	1	61	1	27	2	3	1	6	1	4	1	2.2	3				
T25	4-24-62-6-W4M	6	38	2	36	1	2.4	1	10	2	62	2	30	2	3	1	4	1	1.6	5	.8	3	13	1	21	03
T33	5-32-65-1-W4M	8	37	8	31	6	1.5	.2	12	1	67	1	29	1	2	1	2	1	.6	7	.5	.5	8	3	41	05
T38	4-36-64-7-W4M	3	35	1	38	2	2.2	1	12	4	56	1	33	3	4	1	2	4	8	5	1.8	8				
T41	3-29-58-3-W4M	7	35	1	32	2	2.5	3	11	5	62	4	24	4	2	5	7	1	.2	3	1.9	1.0				
T43	16-28-61-7-W4M	4	35	2	40	2	2.5	3	10	1	62	2	24	4	4	1	8	1	.4	.4	1.0	4				
T44	14-24-61-6-W4M	8	33	1	39	3	2.5	.2	10	1	67	2	23	1	3	1	7	2	1.2	1.3	.8	2				
		2	42	2	34	1	2.5	1	9	-	68	3	26	1	2	3	5	3	2	2	.6	4				
T45	1-9-60-7-W4M	18	30	5	40	6	2.1	.5	11	1	65	4	22	3	3	1	8	3	.4	.3	1.7	8	15	1	20	03
T47	12-36-60-6-W4M	5	29	3	40	2	1.9	1	11	3	61	3	29	2	3	2	6	2	6	7	1.0	.6				
T51	1-16-59-7-W4M	8	33	1	38	1	2.3	2	10	1	66	3	22	4	3	1	7	2	2	1	9	7				
T56	14-6-63-4-W4M	4	37	1	37	1	2.9	3	10	1	66	1	28	1	5	1	7	2	2	1	1.4	1.0				
T59	1-21-63-3-W4M	3	35	6	40	7	2.2	6	11	1	57	4	29	.5	4	1	6	2	7	4	4.1	1				
T66	12-29-63-6-W4M	6	32	1	41	2	2.3	3	9	1	62	2	28	2	2	1	6	1	5	4	1.2	5				
T73	9-6-66-7-W4M	7	22	2	43	2	1.3	2	12	.4	60	2	32	3	4	1	2	1	0	-	1.9	4				
77SR8	11-25-61-11-W4M	18	33	5	32	4	2.1	.3	10	1	65	4	25	3	2	1	7	2	5	6	8	4				
77SR9	16-7-60-8-W4M	23	31	2	41	2	2.0	2	9.5	-	68	3	21	2	3	1	8	2	3	3	1.2	6				
77SR12	1-15-60-10-W4M	10	35	3	40	4	2.6	1	10	1	61	3	25	3	2	1	9	3	2	.3	7	1				
77SR17	15-9-61-6-W4M	2	36	1	43	1	1.8	-	9	2	61	1	27	2	3	2	6	3	2	-	1.5	6				
77SR20	1-25-63-11-W4M	7	23	1	43	5	.8	.1	11	2	59	4	32	4	3	1	4	1	2.2	1.4	1.0	5				
77SR22	3-30-64-13-W4M	8	30	2	39	2	9	2	13	1	64	3	28	4	4	1	4	1	1.5	9	8	5				
77SR24	9-19-66-12-W4M	6	31	3	30	3	1.0	2	12	1	58	4	29	2	4	1	4	1	2.0	8	1.7	9				
77SR34	16-20-66-5-W4M	9	42	1	34	1	1.9	3	12	1	66	3	27	2	2	1	4	1	.7	7	1.5	9				
Mean of the mean values from all testholes			32	5	38	4	2.0	.6	62	4	27	3	3	1	6	2	8	1.3	1.6	1.5	13	3	25	08		
Total number of samples -n			n = 227		n = 227		n = 227		n = 227		n = 227		n = 227		n = 227		n = 227		n = 227		n = 227		n = 54		n = 54	
Total number of testholes -N			N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 16		N = 30		N = 6		N = 6	

X - Mean
S.D. - Standard Deviation

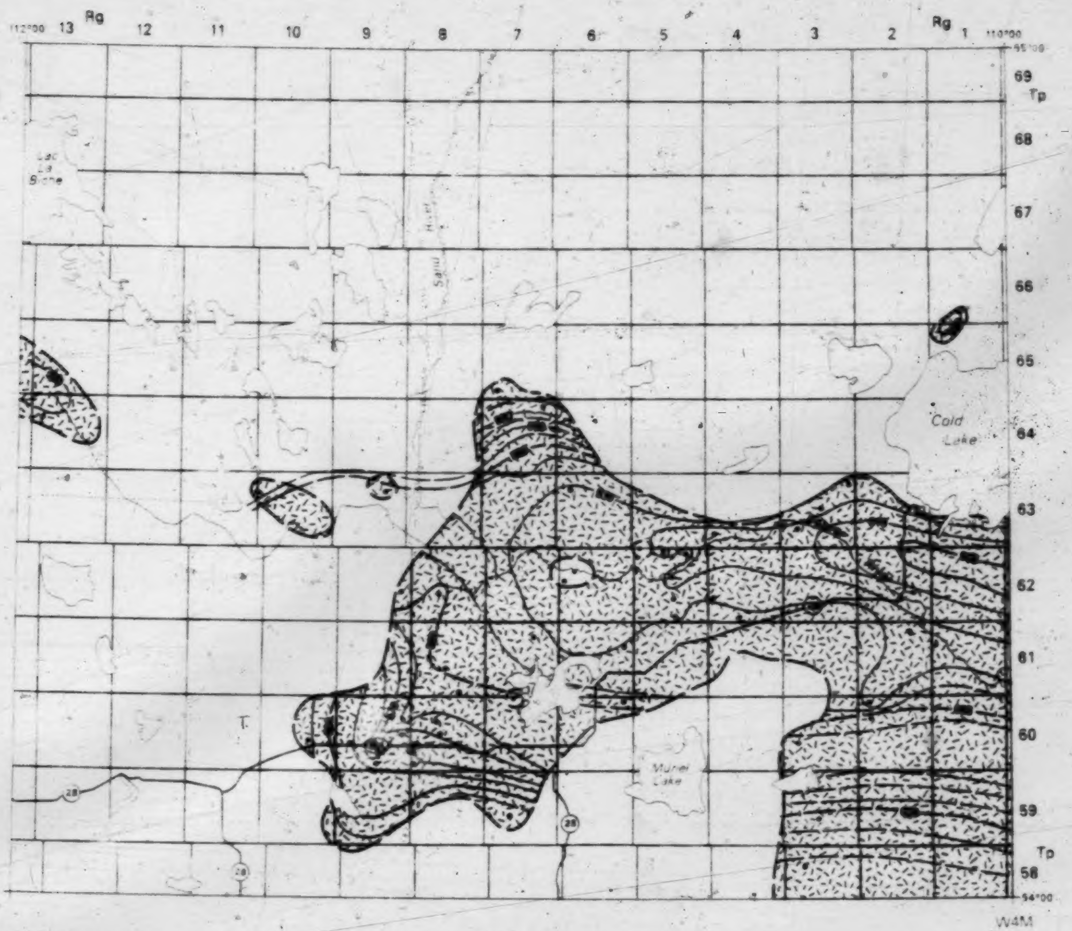

112°00
13
Rg
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
W4M
Lac La Biche
Sand River
Cold Lake
Muriel Lake
28

Figure:33 Elevation of the upper surface of unit 1 of the Marie Creek Formation.

▨ Diamicton (till)

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - -

Contours, Interval 10 metres:
Defined .... —500—
Approximate .... — —500— —

Data Location .... •

been mapped above segments of the buried Helina Valley in the northwest, but the extent of these is not well known. The unit ranges in elevation from as high as 620 m within the Reita Lake Uplands in the southeast, and the Lac LaBiche Uplands in the southwest, to as low as 500 m within a small valley south of Cold Lake (Figure 33). Unit 1 is generally thin within the map area, particularily within the Beaver River Lowland plain and Reita Lake Upland where commonly it is less than 5 m thick (Figure 34). Unit 1 is thickest within the Kehiwin Upland in the southwest, where as much as 25 m are mapped within a northeast-southwest oriented deposit.

Differentiation from other units

Unit 1 is differentiated from unit 2 of the Marie Creek Formation primarily on the basis of matrix texture. Unit 1 is more clayey and commonly contains discrete lenses and partings of silt and clay in the form of clasts. Both units have a similar very coarse sand composition, except that unit 1 does not contain the very high dolostone and dolomite facies which lies at the top of unit 2 (Table 2).

It may be more proper to consider the clayey unit 1 as a textural facies of the sandier unit 2 of the Marie Creek Formation. The reason for this is that unit 1 commonly is characterized by silt and clay "clasts" imbedded in a sandy diamicton, which is similar to the sandy diamicton of unit 2. The distribution and thickness of this clayey diamicton can be mapped over a wide area however, and its differentiation from unit 2 is not only easy, but useful for describing and correlating the Marie Creek Formation throughout the map area.

Unit 1 is differentiated from the till of the underlying Bonnyville Formation primarily on the basis of the very coarse sand composition: unit 1 contains considerably more calcareous material, and considerably less quartz than the Bonnyville Formation (Table 2).

Nature of Contacts

Lower Contact

The contact of unit 1 with the underlying Ethel Lake Formation is generally gradational, and shows incorporation of the underlying silt and clay (Appendix A, testholes T-13B and T-15). The contact is considered to be conformable.

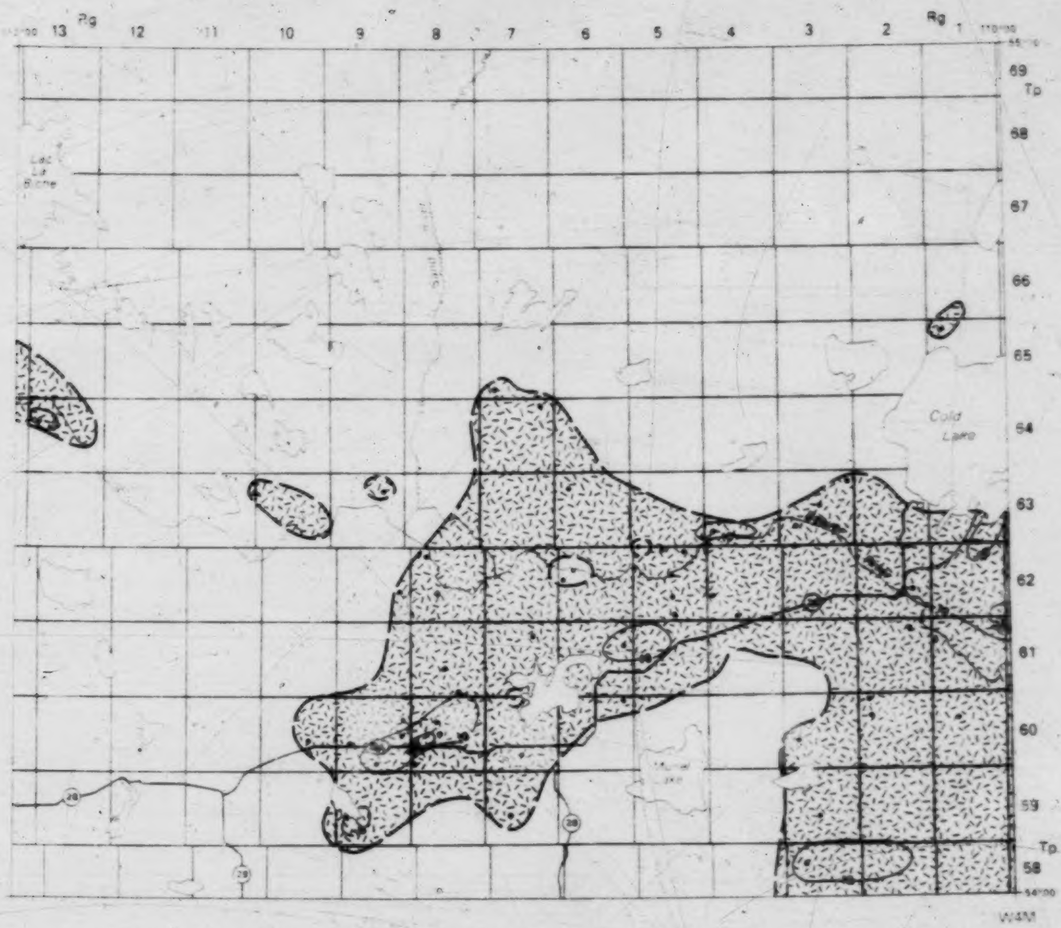

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Lac La Biche
Cold Lake
28
28
W4M

Figure:34 Thickness of diamicton in unit 1 of the Marie Creek Formation.

▨ Diamicton (till)

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -
Isopach, Interval 10 metres .... ═══
Data Location .... •

Within large areas in the Beaver River Lowland Plain the underlying Ethel Lake Formation has been completely eroded and incorporated into unit 1. In these areas unit 1 overlies the sandy till of the Bonnyville Formation. The contact is generally sharp and well defined on the basis of textural properties. (Appendix A, testholes T-44, T-59).

Upper Contact

The contact of unit 1 with the base of unit 2 is generally gradational (Appendix A, testholes T-6, T-12, T- 14,) though in places can be sharp and abrupt (Appendix A, testhole T-3). In the field the contact is commonly recognized within the dry-auger samples at the first occurrence of thin silt and clay layers within the diamicton. In this study however, the top of unit 1 is defined from the analytical textural values, generally at the depth where the amount of clay exceeds the amount of sand in the diamicton.

Resistivity responses commonly show that the top of unit 1 is gradational with the base of the overlying unit 2, and therefore are not very useful for establishing the contact.

C. Unit 2

Description of unit

Unit 2 of the Marie Creek Formation is widespread over much of the Sand River map area. It is characterized by a sandy diamicton, the top of which is weathered and highly oxidized olive (5Y 4 / 4) to olive brown (2.5Y 4 / 4) in many places. This oxidized profile has been mapped both in outcrop and within testholes, buried at depths as much as 35 m (Plate 1 and Appendix A, testhole T-7).

Outcrop observations reveal that the oxidation pervades throughout the entire sample (Plates 1 and 2). Below this oxidized horizon the diamicton is unoxidized dark grey (5Y 4 / 1). The upper part of the oxidized horizon is commonly highly fractured, forming angular shards or blocks about 6 cm in length, 3 cm in width, and 2 cm in thickness (Plate 2). Iron or manganese staining can be found along the joint surfaces and fracture planes (Plates 1 and 2). The degree of fracturing diminishes such that only large scale joints, spaced a few meters apart, are present at depth. The fractured structure, combined with the sandy texture of the unit, results in the upper part being easy to excavate with a pick or backhoe, even though the formation as a whole is very dense and consolidated.

A concentration of boulders is recognized at the contact of unit 2 with the overlying Grand Centre Formation in some places (Plate 3). It is uncertain as to which of the formations the boulder concentration belongs to, but in section SRA-200, located in LSD 11, Sec 1, Tp 63, Rg 3, W4M, a boulder concentration is also mapped at depth within the Marie Creek Formation (Plate 3). This suggests that likely more than one boulder concentration is associated with unit 2.

Numerous sand and gravelly sand lenses are bedded within the diamicton in section SRA-200, located along the Marie Creek in the east. In places these lenses are so numerous so as to produce a poorly stratified appearance to the outcrop (Plate 4). These sand lenses vary in length from centimetres to metres and are about 15 to 20 cm thick. Typically most of the lenses are horizontally or nearly horizontally bedded. The extent of these lenses beyond the Marie Creek area is unknown primarily because exposures are limited.

The average matrix texture of unit 2 is about 41% sand, 30% silt, and 29% clay (Table 2). The textural variations range between 35% to 45% sand, 30% to 40% silt, and 25% to 35% clay (Table 7). The diamicton characteristically contains abundant pebbles and clasts, and is relatively rich in the very coarse sand fraction (2.7%, Table 2). The sandy, consolidated nature of unit 2 yields a relatively low moisture content, which ranges between 9% and 10% (Table 7). This results in the upper part of unit 2 being difficult to penetrate with a dry auger.

The composition of the very coarse sand fraction averages about 61% igneous and metamorphic rocks, 21% quartz fragments, 4% limestone, 13% dolostone, less than 1% quartzite and quartz sandstone, and 1-2% local rocks (Table 2). The variations range between 55% to 65% igneous and metamorphic fragments, 15% to 25% quartz fragments, 3% to 6% limestone, as much as 19% dolostone, less than 2% quartz sandstone and quartzite, and 1% to 2% local rock fragments (Table 7).

Calcareous material makes up as much as 20% of the silt-clay fraction with dolomite much more abundant than calcite (calcite / dolomite ratio = .17, Table 2). On the

Table 7. Properties of unit 2 of the Marie Creek Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy														Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dol. %		Grnte & Qtz. Sst. %		Local %		CO₃ %		Calcite Dolomite %	
			X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.
T2	4-15-85-2-W4M	7	44	3	30	4	3.3	.3	9	.7	61	3	21 28	- 3	4	.6	14 4	- 1	1.1	.4	1.7	.8				
T3	6-36-61-1-W4M	7	46	2	28	3	3.1	.3	11	.5	56	2	21 32	2 4	5	1	16 4	1 3	.9	.5	1.4	.6				
T5	2-18-59-3-W4M	14	38	3	29	2	3.0	.3	9	.7	61	2	21	2	4	1	13	3	.7	.3	1.1	.5	19	1	.17	.04
T6	15-31-62-3-W4M	14	44	2	29	2	2.8	.4	9	1	61	3	18	3	4	1	15	3	1.2	.9	1.9	1	19	2	.14	.04
T7	4-1-64-6-W4M	7	38	1	30	1	2.6	.2	11	.3	57	3	21	2	4	1	17	2	.2	.2	1.2	.7	18	1	.16	.03
T8	11-36-62-2-W4M	2	47	1	28	1	3.3	.3	9	1	58	1	28	2	4	1	8	1	.3	.3	.7	0				
T9	13-10-62-2-W4M	6	42	3	29	2	3.1	.4	9	.4	61	3	19 24	2 5	3	1	15 8	1 2	.5	.5	1.2	.8				
T10	9-18-63-4-W4M	3	37	4	32	3	2.2	.2	12	1	60	3	25	3	8	1	7	2	.9	-	2.0	.4				
T11	9-14-62-6-W4M	7	43	2	27	2	2.6	.4	10	.5	66	4	21 28	3 4	3	1	11 5	1 1	.3	.7	.9	.5				
T12	4-4-62-4-W4M	5	41	3	27	3	3.5	.4	9	.4	60	3	21	1	5	.5	14	1	.2	.2	1.3	.8				
T13	4-27-60-2-W4M	9	38	2	32	1	2.7	.3	11	.5	62	3	19	2	8	2	12	2	.5	.5	1.0	.3				
T13B	1-30-60-2-W4M	12	38	1	33	1	2.7	.2	10	.4	60	3	21 23	2 3	4	1	12 9	2 1	.5	.5	1.4	.6				
T14	4-17-60-3-W4M	16	36	2	28	3	2.7	.2	9	1	60	2	19 22	2 3	4	1	13 9	1 2	.5	.3	1.7	1.1				
T15	16-20-60-1-W4M	4	39	1	28	1	2.3	.3	10	3	60	4	17	1	6	2	13	2	.8	.4	2.8	.4				
T16	4-30-61-1-W4M	9	46	4	25	3	3.0	.3	10	1	66	2	21	3	4	1	10	3	.5	.4	1.5	1				
		4	37	0	32	1	2.0	.4	11	1	70	2	18	2	4	1	8	1	.5	.4	1.8	.8				
T17	7-36-61-3-W4M	19	47	4	29	3	2.7	.3	9	1	63	4	22 28	3 4	3	1	11 2	3 1	.5	.4	1.8	.8				
T18	9-18-61-3-W4M	11	42	3	29	4	2.8	.4	9	1	67	4	18 21	2 1	3	2	14 8	2 1	.4	.4	1.3	.5				
T19	16-30-64-2-W4M	18	46	4	25	2	3.3	.5	10	3	66 61 71	1 3 3	22 28 34	1 2 2	4 4 2	1 1 1	14 4 2	1 1 4	.5 .5 .5	.2 .2 .2	2.0 2.0 .8	.7 .7 .4				
T20	1-26-64-5-W4M	5	50	2	23	2	2.8	.2	10	.5	66	3	39	2	4	3	8	1	.2	.2	1.7	.8				
T22	7-19-66-5-W4M	14	53	4	20	4	4.0	1.0	10	1	64 53	3 1	28 40	3 4	3	1	4	2	.4	.5	1.1	.7				
T23	15-22-64-6-W4M	6	42	6	28	7	2.4	.4	12	1	66	2	32 38	1 2	4	1	8 3	1 1	.5	.3	1.0	.4				
T25	4-24-62-6-W4M	8	41	3	25	3	2.7	.2	9	1	57	2	24	3	5	1	11	2	.7	.8	0		20	2	.14	.02
T27	4-8-64-3-W4M	4	41	2	27	1	2.8	.3	9	.3	66	1	19 23	- 1	3	1	13 8	- 1	.4	.3	.3	.4				
T29	9-34-63-2-W4M	11	42	3	30	2	2.9	.2	10	1	58	4	21 27	2 4	4	1	18 5	3 1	1.0	.9	2.2	1.3				
		5	48	1	24	1	3.6	.2	10	1	62	1	27	1	5	1	3	3	.8	.5	1.7	.6				
T30	13-4-62-3-W4M	13	42	4	30	4	2.8	.4	9	1	60	2	22 34	2 3	3	1	9 3	2 2	.6	.5	.8	.2	16 11	2 -	.19 .28	.01 -
T32	12-1-64-3-W4M	5	40	1	31	1	2.4	.1	9	1	60	2	17 21	1 2	4	1	11 8	2 1	.8	.8	1.8	.5	17	1	.18	.02
		4	52	5	23	3	3.0	.5	7	1	58	2	32	2	4	1	8	1	.8	.8	1.9	.9	12	3	.28	.02
T33	5-32-66-1-W4M	17	42	2	31	2	2.9	.3	11	.6	58	2	21 21	2 2	4	1	11 7	2 1	.6	.4	.6	.4	16 14	1 2	.17 .18	- .1
		14	48	1	23	5	2.9	.3	10	.6	60	2	27	3	4	1	3	1	.5	.4	1.7	.7	12	1	.28	.04
T34	13-18-63-2-W4M	8	48	1	27	2	3.8	.3	10	2	60	3	26	2	4	1	3	.4	.7	.8	3.2	1.7				
T38	13-4-62-6-W4M	1	48	-	19	-	3.5	-	11	-	60	-			3	-	28	-			.6		0	-	.8	

X - Mean
S.D. - Standard Deviation

Table 7(cont'd)

	LSD-Sec-Tp-Rg-W4M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Carb. %		Lst. %		Dol. %		Shale & Clas. Sed. %		Local %		CO_3 %		Calcite Dolomite %	
			X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.
T38	4-28-64-7-W4M	9	43	1	28	2	2.7	2	11	1	58	3	28 30	 1	4	1	15 5	 2	6	5	1.5	7				
T41	3-29-68-3-W4M	17	38	2	31	2	2.7	3	10	4	48	2	38	4	3	1	10	1	8	1.5	1.3	7				
T42	13-5-68-3-W4M	10	41	1	31	1	2.8	3	9	3	60	3	23	2	3	1	11	2	1.1	6	1.1	7				
T43	16-28-61-7-W4M	3	38	2	35	2	2.3	3	10	1	61	6	23	4	4	2	16	2	4	4	1.8	1.3				
T44	14-24-61-6-W4M	10	40	1	28	2	2.9	3	10	6	62	4	19	2	4	2	15	4	2	3	2.2	8				
T46	1-9-60-7-W4M	5	37	1	28	4	2.7	1	11	2	59	2	30	1	4	1	14	3	7	2	2.4	7	18	1	16	01
T47	12-36-65-6-W4M	3	35	5	27	6	2.4	3	11	1	54	2	23	2	5	2	13	3	7	1	1.2	7				
T48	4-28-60-4-W4M	11	37	3	25	3	2.5	3	10	1	58	4	33	2	5	2	14	3	1	2	1.5	1.0	20	1	15	08
T49	16-12-61-5-W4M	16	42	3	22	3	3.3	7	9	1	61	3	19 28	2 1	4	1	15 7	4 1	4	2	1.2	7				
T50	16-10-58-5-W4M	23	43	1	31	1	2.5	2	10	5	48	3	38	3	3	1	3	1	3.3	1.0	1.3	.6				
T51	1-16-58-7-W4M	11	38	2	34	1	2.7	4	10	6	58	4	18 22	3 3	2	1	12 8	7 2	2	1	1.4	8				
T52	3-5-60-4-W4M	8	40	1	28	1	3.1	3	11	2	58	3	38	2	8	1	3	2	1.0	7	3.4	1.3				
T54	3-36-60-0-W4M	4	38	3	33	1	2.6	2	11	1	58	3	22	2	4	1	17	1	0		1.3	3				
T56	14-6-62-4-W4M	7 5	38 48	2 3	27 24	4 2	2.6 3.1	2 4	8 9	4 5	59 60	1 1	22 24	2 1	4 4	1 1	15 12	2 2	1 1	1 1	0 0					
T58	16-13-62-2-W4M	7	46	1	28	1	3.2	3	8	4	65	1	23 28	 2	4	1	9 3	 1	1.1	5	2.2	1	18 14	 4	19 38	 08
T59	1-21-60-3-W4M	10	46	3	26	2	3.0	5	8	4	58	4	20 28	3 4	4	1	13 8	1 1	7	4	1.4	8	17 15	1 2	14 28	20 38
T61	4-25-58-6-W4M	8	38	1	31	1	2.8	1	9	4	58	2	28	2	4	1	12	1	5	4	1.1	8				
T66	11-28-62-6-W4M	7	38	3	28	4	2.8	3	9	1	50	2	21	2	4	1	14	1	7	6	7	3				
T72	8-1-60-1-W4M	6	38	1	31	1	3.2	3	10	2	60	4	28 30	2	3	1	9 4	2 2	0	4	1.9	4				
T73	5-6-65-7-W4M	8	42	2	22	1	2.8	2	10	3	62	3	34	2	3	1	9	1	2	2	9	4				
T74	11-1-63-3-W4M	10	44	1	31	1	2.6	2	8	2	64	3	28	2	3	1	8	1	9	4	2.0	7				
77SR7	16-28-58-11-W4M	8	41	2	31	2	2.2	2	10	4	62	2	38	3	2	1	6	1	1.2	4	1.2	5				
77SR8	11-28-61-11-W4M	6	34	4	28	2	2.2	3	9	1	53	3	19	3	6	1	19	4	2	2	3.4	4				
77SR9	16-7-60-8-W4M	24	38	1	35	3	3.2	1	8	1	48	3	19 19	2 2	3	1	9 9	2 2	5	6	9	6				
77SR17	15-0-61-8-W4M	5	37	2	35	6	2.4	1	8	1	62	3	19	3	3	1	18	3	5	2	1.3	5				
77SR18	9-2-65-8-W4M	4	38	4	28	4	2.0	1	9	1	57	2	25	3	3	1	14	3	3	5	1.1	1				
77SR20	1-26-63-11-W4M	11	35	2	35	3	1.1	3	10	1	52	4	33	2	5	2	5	1	3.1	1.0	1.6	7				
77SR22	3-20-64-13-W4M	7	38	3	38	4	1.0	1	12	1	58	3	38	4	6	1	5	1	2.2	9	2.0	1.0				
77SR23	11-28-65-10-W4M	6	38	2	28	2	2.3	2	10	2	68	2	28	4	3	1	6	1	4	3	1.5	6				
77SR24	9-19-66-12-W4M	6	38	1	28	1	1.7	5	11	6	48	2	28	2	3	1	4	1	1.2	1.3	6	6				
77SR34	16-20-68-5-W4M	12	46	2	27	2	2.7	2	10	4	52	5	19 27	 4	3	1	11 4	 1	4	4	2.3	1.0				
77SR38	2-6-68-4-W4M	9	42	1	30	1	2.8	3	10	6	54	3	20	2	3	1	12	3	1.2	5	1.4	8	15	6	19	08
77SR39	9-24-66-W4M	17	46	3	28	2	3.1	5	10	1	58	3	15 22	1 3	4	1	13 8	3 1	1.2	5	1.8	7	15 13	9 9	19 30	08 08
		6	50	1	22	1	3.3	2	10	4	67	2	21	3	4	1	5	1	8	6	1.9	6	14	2	32	08
High Dolostone Facies																										
Mean of the mean values from all testholes (excluding very sandy basal facies)			41	4	29	3	2.7	5	10	1	61	4	21	3	4	2	13	2	7	6	1.5	7	17	2	17	08
Total number of samples -n			n = 538		n = 538		n = 538		n = 538		n = 538		n = 288		n = 538		n = 270		n = 538		n = 538		n = 132		n = 132	
Total number of testholes -N			N = 62		N = 62		N = 62		N = 62		N = 62		N = 40		N = 62		N = 40		N = 62		N = 62		N = 14		N = 14	
Low Dolostone Facies																										
													28	2			6	2					13	2	28	08
													n = 277				n = 284						n = 40		n = 40	
													N = 38				N = 38						N = 6		N = 6	
High Dolostone Facies																										
Mean of the mean values from all testholes where very sandy basal facies present			40	2	23	1	2.2	3	9	1	62	3	24		4		12	2	8	3	1.0	3				
Total number of samples -n			n = 34		n = 34		n = 34		n = 34		n = 34		n = 34		n = 5		n = 5									
Total number of testholes -N			N = 5		N = 5		N = 5		N = 5		N = 5		N = 5		N = 1		N = 1									
Low Dolostone Facies																										
													27	4			6	1					13	1	28	08
													n = 29				n = 29						n = 19		n = 19	
													N = 4				N = 4						N = 3		N = 3	

X - Mean
S.D. - Standard Deviation

basis of carbonate content, unit 2 can be divided into two facies (Tables 2 and 7). The upper facies is particularily rich in dolostone and relatively low in quartz fragments in the very coarse sand fraction and, rich in dolomite in the silt-clay fraction. The lower facies contains less calcareous material but even so, the values are still relatively higher than those of the other formations (Table 2).

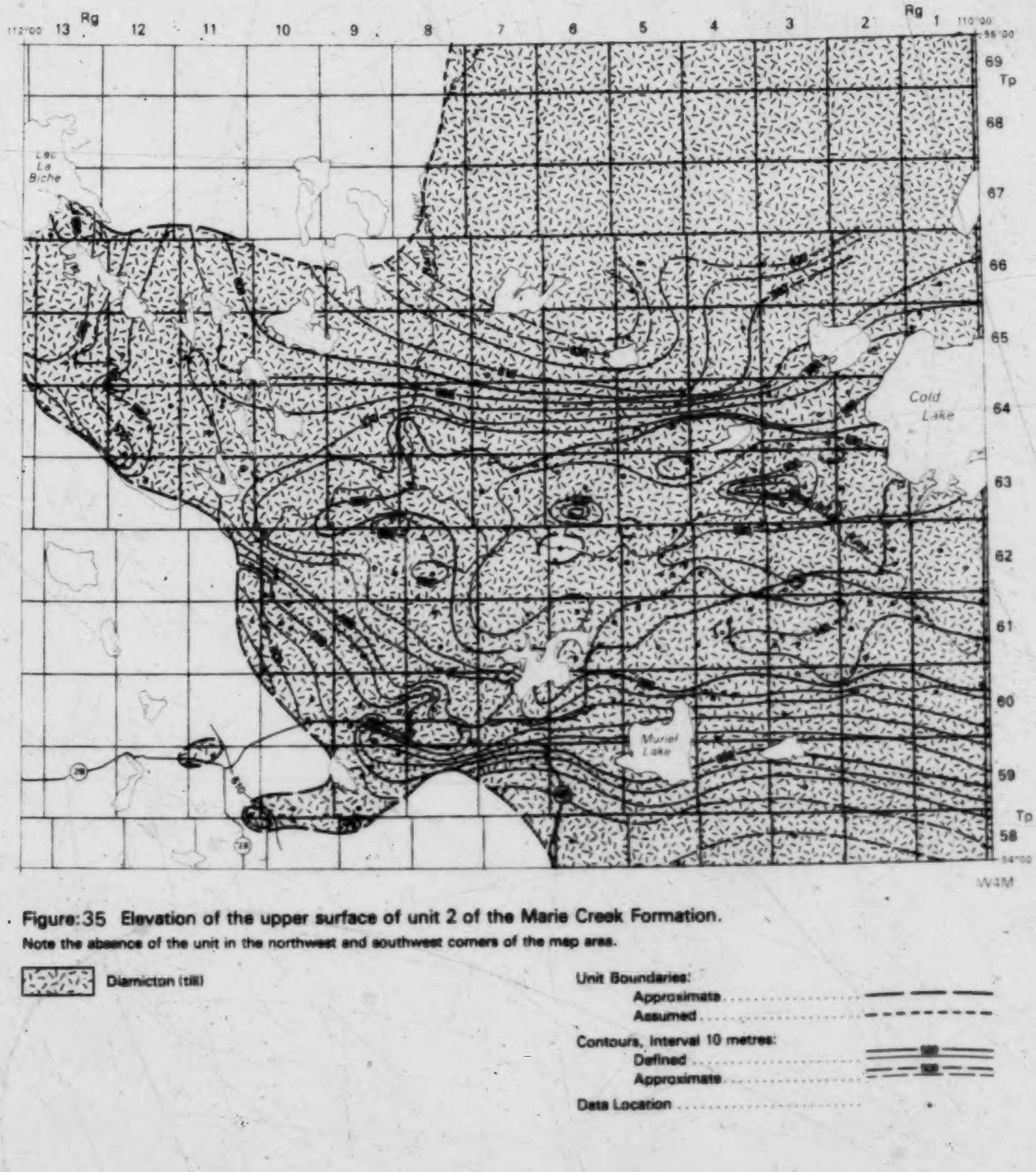
The clay mineralogy of a few representative samples of unit 2 consists of about 53% to 61% illite, 18% to 26% kaolinite, 13% to 20% montmorillonite, and 5% to 8% chlorite (Appendix B).

Resistivity responses show that the top of unit 2 has a distinctly higher resistivity compared to the overlying Grand Centre Formation (Figure 10). This higher resistivity likely results from the combined effects of the fractured, oxidized horizon, sandy texture, low moisture content, and high matrix carbonate content of unit 2.

Distribution, Thickness, and Subcrop Topography

Unit 2 is extensive in the eastern half and central parts of the Sand River map area, but is not recognized in the southwest or northwest regions (Figure 35). It is believed to have once been present in the northwest, but likely was eroded by the last glaciation in the area. The evidence for this is given in the section which discusses the differentiation of the Marie Creek Formation and the Grand Centre Formation. The southwest limit of unit 2 is defined by a northwest-southeast trending margin which extends from Tp 65, Rg 13 to Tp 58, Rg 7. Along this margin unit 2 terminates against the northeast flank of the underlying upland, except for a small lobe-form which extends southwest along a shallow depression above the buried Beverly valley in Tps 58-59, Rgs 9-11 (Figure 35). The northern extent is uncertain because data are lacking.

Unit 2 forms an asymmetrical profile on the uplands flanking the Beaver River Lowland Plain: it rises abruptly along the northern margin of the Beaver River Lowland plains to form a distinct scarp on the southern edge of the Marguerite Lake Uplands, but rises much more gradually along the southern margin on the north slope of the Reita Lake, Moose Lake, and Kehiwin Lake Uplands (Figures 8, x-secs. E1-E1′ and E2-E2′, and 35). The top of unit 2 lies at an elevation as high as 640 m within the Reita Lake and Marguerite Lake Uplands, and as low as 510 m along the Beaver River Lowland Plain in Tp 63, Rgs 3-4



112°00
Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
W4M
Lac La Biche
Cold Lake
Muriel Lake
28
28

Figure:35 Elevation of the upper surface of unit 2 of the Marie Creek Formation.

Note the absence of the unit in the northwest and southwest corners of the map area.

▨ Diamicton (till)

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -

Contours, Interval 10 metres:
Defined ....
Approximate ....

Data Location .... •

(Figure 35).

Figure 35 shows that no major drainage systems have been recognized on the surface of unit 2. One minor system in the southwest corner in Tp 59, Rg 9 is believed to have drained northeast into the Beaver River Lowland Plains.

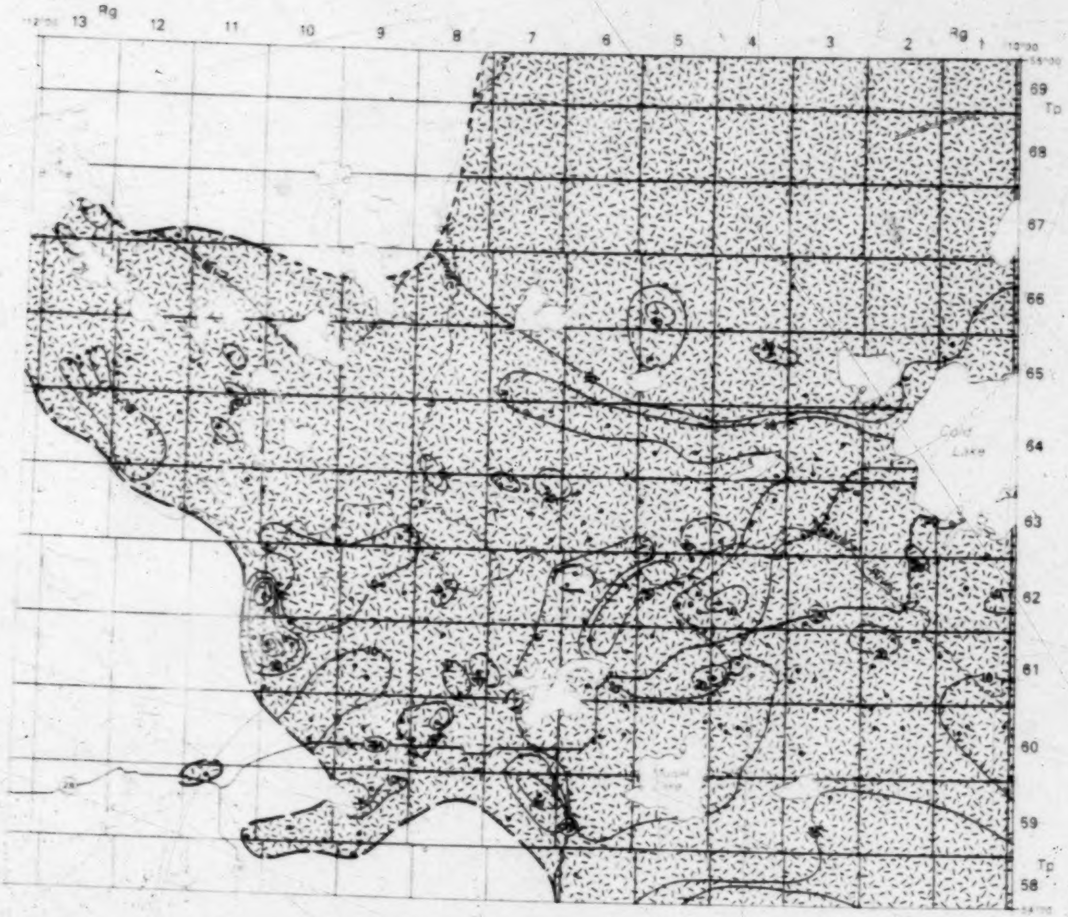
Unit 2 is at least 10 m, and commonly 20 m, thick over much of its extent (Figure 36). The exception is the large area of thin deposits along two trends within the Beaver River Lowland Plain. One trend extends northward from Muriel Lake in Tp 59, Rg 6, to Marie Lake in Tp 64, Rg 2. The other trend follows the base of the scarp along the south edge of the Marguerite Lake Uplands in Tp 64, Rgs 2-7. Unit 2 is generally less than 9 m thick and locally may be absent within both these trends. The thickest deposits of unit 2 are found primarily in the Reita Lake and Marguerite Lake Uplands where as much as 47 m have been mapped (Figures 8, x-sec E2-E2', and 36). Other areas of thick deposits are found along the southwest margin of the unit in Tp 61, Rg 10, and above segments of the buried Beverly, Helina, and Big Meadow Valleys where it infills a topographic low on the surface of the Bonnyville Formation.

Because unit 1 of the Marie Creek Formation is thin in most places the total thickness of the formation does not differ much from that of unit 2. Figure 37 shows that although this is true for most of the formation, there are some areas where the combination of the two units produces thick deposits. One such area is in Tp 61-63, Rg 2-6. Here the geometry shows that thick deposits of the Marie Creek Formation lie within a valley on the surface of the underlying Bonnyville Formation (Figure 26). Interestingly, this valley is expressed as a poorly defined valley on the surface of the Marie Creek Formation as well (Figure 35).

Differentiation from other units

Unit 2 is differentiated from all other units primarily on the basis of its high carbonate content, particularily dolostone and dolomite, and relatively high resistivity values.

In the east, where unit 2 of the Marie Creek Formation and unit 2 of the Bonnyville Formation are both sandy, they are differentiated on the basis of the very coarse sand composition: unit 2 of the Marie Creek Formation contains much more carbonate,



112°00
13
Rg
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
Cold Lake

Figure: 36 Thickness of diamicton in unit 2 of the Marie Creek Formation.

Note the isolated areas of thick deposits along the southwest boundary of the unit.

▨ Diamicton (till)

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -
Isopach, Interval 10 metres .... ═══ 50 ═══
Data Location .... •

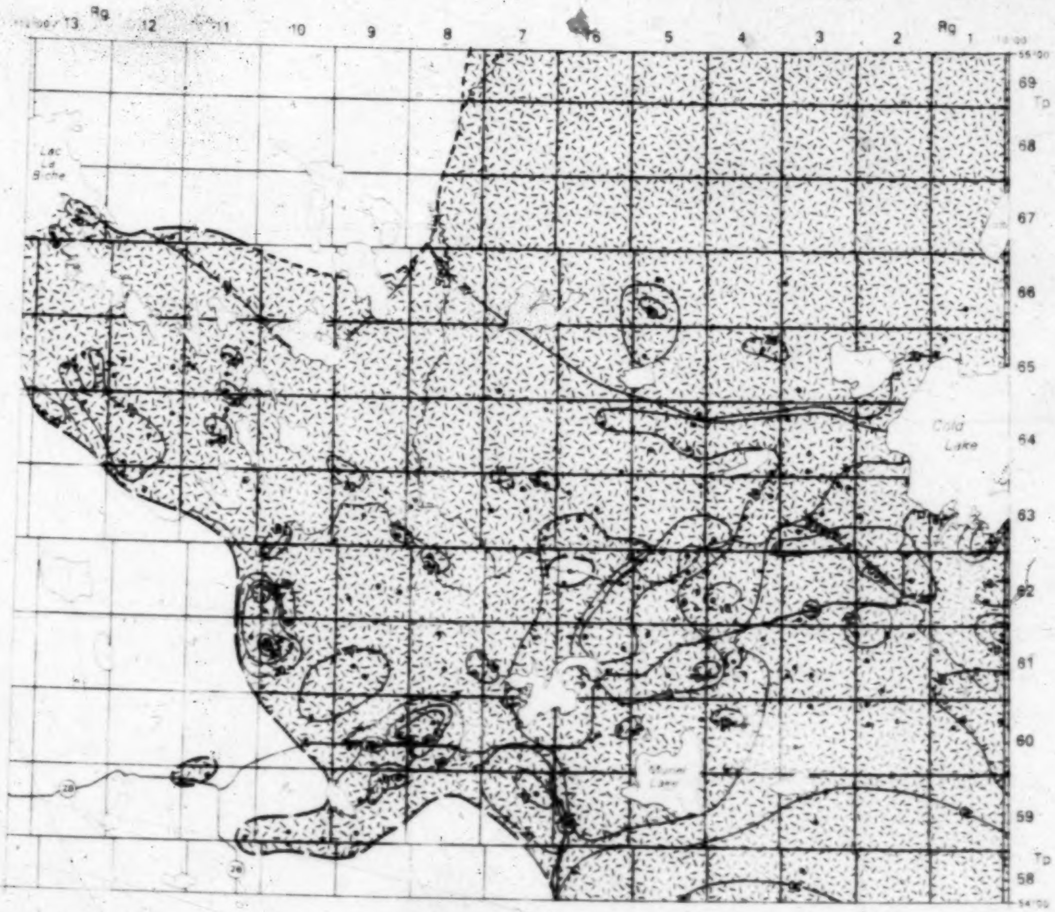

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
Lac
La
Biche
Cold
Lake
Muriel
Lake
28

Figure 37 Total thickness of units 1 and 2 of the Marie Creek Formation.
Note the thick deposits along the southwest boundary.

▨ Diamicton (till)

Unit Boundaries:
- Approximate
- Assumed

Isopach, Interval 10 metres

Data Location

particularily dolostone, and much less quartz than does the Bonnyville Formation (Table 2). As well, the two can be differentiated by their drilling characteristics and electric log responses: unit 2 of the Marie Creek Formation is generally more consolidated and difficult to drill, where as the Bonnyville Formation tends to be loose and softer. Generally the top of unit 2 of the Marie Creek Formation has a higher resistivity than the top of unit 2 of the Bonnyville Formation (Figure 8, x-sec E2-E2', testhole E1712), though with depth, unit 2 becomes less resistive and the contrast is not as apparent.

Unit 2 of the Marie Creek Formation is differentiated from the various members of the overlying Grand Centre Formation on the basis of color, structure, texture, lithic composition and resistivity responses. With the exception of the Kehiwin Lake Member, unit 2 of the Marie Creek Formation is more highly oxidized and has an olive-brown color which contrasts to the dark grey-brown color of the Grand Centre Formation (Plate 4). As well, the top of unit 2 is commonly highly fractured and well-jointed, and this differentiates it from the massive, structureless outcrop appearance of the clayey members of the Grand Centre Formation. Texturally, unit 2 of the Marie Creek Formation is more sandy than most of the members of the Grand Centre Formation, particularily in the amount of very coarse sand (Table 2). This abundance of very coarse sand enables unit 2 to be differentiated from the Grand Centre Formation in the field, even in those areas where the overall matrix textures of the two formations are similar (Appendix A, testhole T-16). Unit 2 is generally more difficult to penetrate with a dry auger compared to the Grand Centre Formation, presumably because it is more sandy and drier. Unit 2 contains significantly more calcareous material, particularily dolostone and dolomite, in both the very coarse sand and silt-clay fractions, than does the Grand Centre Formation (Table 2). As well, unit 2 contains less igneous and metamorhpic rock fragments in the very coarse sand fraction than does the Grand Centre Formation (Table 2). In almost all places the top of unit 2 has a higher resistivity than the base of the overlying Grand Centre Formation (Figure 10). This property is useful for differentiating unit 2 in areas where analytical data are not available.

In the western part of the map area the differentiation between unit 2 of the Marie Creek Formation and the Grand Centre Formation is more difficult. This is because the distinctive sandy texture and upper high dolostone facies unit 2 is absent, likely because of glacial erosion. Evidence for glacial erosion is the presence of displaced slabs of the high dolostone facies of unit 2, found as incorporated blocks within the Vilna Member (Figure 9, x-sec N1-N1', testhole 77SR-12 and Appendix A). However, the total amount of calcareous material in the very coarse sand fraction is generally higher for unit 2 and this differentiates the two formations (Appendix A, testholes 77SR-20, 77SR-23, and 77SR-24).

Nature of Contacts

Lower Contact

The contact of the Marie Creek Formation with the underlying Ethel Lake Formation is generally gradational, as discussed in the description of unit 1 of the Marie Creek Formation. In some places however, unit 2 of the Marie Creek Formation has a sharp contact with the Ethel Lake Formation (Figure 29, testhole T-32).

In those areas where unit 2 of the Marie Creek Formation directly overlies the Bonnyville Formation, the contact is varied. In some places it is sharp and can be easily recognized from the resistivity logs (Figure 5, testhole E804). In other places the contact is gradational, especially with respect to the texture and very coarse sand composition. As an example, in testholes T-18, T-27, and T-32 (Appendix A and Figure 29) unit 2 of the Marie Creek Formation becomes increasingly more sandy and quartz rich with depth, acquiring the same textural and lithic composition as the top of the underlying Bonnyville Formation. Interestingly enough, in testhole T-32 the base of unit 2 of the Marie Creek Formation is texturally gradational with the very sandy Bonnyville Formation, even though silt and clay of the Ethel Lake Formation separate the two tills.

On the basis of the oxidized profile on the surface of the Bonnyville Formation (Appendix A, testhole T-41), the contact of unit 2 of the Marie Creek Formation with the Bonnyville Formation is considered to be disconformable.

Upper Contact

The upper contact of unit 2 of the Marie Creek Formation with the base of the stratified deposits of the Sand River Formation is sharp and well defined from both the lithologs and electric logs (Figure 5, testholes E804 and E1708). In most places the top of unit 2 is oxidized suggesting that the contact with the Sand River Formation is disconformable.

The field and analytical data both show that the contact between unit 2 of the Marie Creek Formation and the overlying Grand Centre Formation is generally sharp. Commonly in the east the contact between the two is defined by a boulder concentration (Plate 2), though it is uncertain to which unit the boulders belong.

Gradational contacts between the two units are found in two settings. One area is within the eastern part of the Beaver River Lowland Plain where the Grand Centre Formation is both texturally and lithic compositionally gradational with unit 2 of the Creek Formation (Appendix A, testholes T-10, T-13B, T-25, T-42, T-44, T-49, T-59, T-73). However, even with these gradations, the contact between the two formations is generally well defined on the electric logs.

The other setting is in the western part of the map area where the sandy, high dolostone facies of unit 2 is absent. Here, thick masses of unit 2 of the Marie Creek Formation have been glacially displaced and incorporated into the Grand Center Formation (Figure 9, x-sec N1-N1', testhole 77SR-12).

D. Origin and variations in the till properties

Diamicton of both units of the Marie Creek Formation represent till which was deposited during the third major glacial advance in the map area, the Ardmore Glaciation. The abundance of carbonates, particularily dolostone, in the till indicates that a considerable amount of the Devonian Carbonates was eroded compared to the other rock fragments. This suggests that the Ardmore Glacier flowed along the narrow belt of carbonate outcrop rather than across the belt (Geology map of Alberta, Green 1972) implying a flow direction more from the north, or west of north, instead of northeast. Flow from the north, or slightly west of north, is also supported by pebble orientations of the upper part of the Marie Creek Formation, measured in a backhoe section at site

LA81-2 (Figure 38). Here, the fabric shows that in the east part of the map area the pebbles have a preferred north to northwest-south southeast orientation indicating flow from slightly west of north.

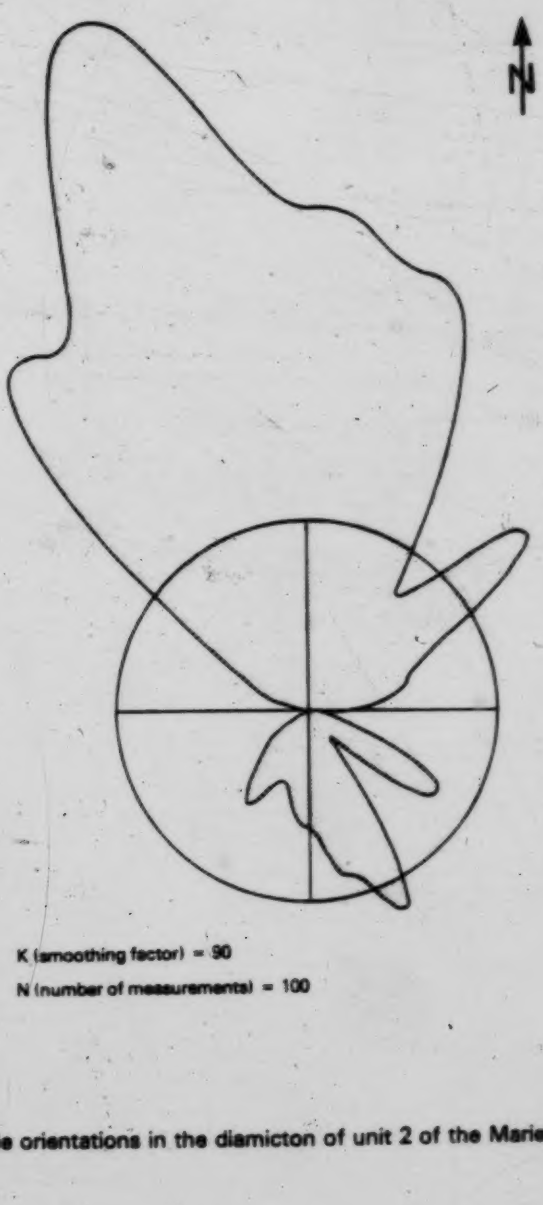
The sporadic distribution of the Ethel Lake Formation in the Beaver River Lowland Plain, combined with the widespread distribution of unit 1 of the Marie Creek Formation in the lowland, is evidence that the clayey till of unit 1 was derived from the underlying silt and clay of the Ethel Lake Formation (Figures 30 and 33). This amount of erosion likely differed from place to place, and this explains why not only are the within hole variations in the texture of unit 1 high, but so is the lateral variation of the mean texture values (Figure 39). The upper parts of the Ardmore Glacier likely did not contain as much incorporated silt and clay of the underlying Ethel Lake Formation, and this may explain why the upper part of the Marie Creek Formation (unit 2) is more sandy.

Not all of the clayey texture of unit 1 can be attributed to incorporation of just the underlying Ethel Lake Formation. For example, in testhole T-3 (Appendix A), located in Tp 61, Rg 1, due south of Cold Lake, unit 1 contains a relative abundance (9%) of locally derived rock fragments, primarily shale, in the very coarse sand fraction. This abundance of shale suggests that in this area unit 1 likely is composed of a significant amount of the Lea Park Formation, which once outcropped or subcropped along the southern flank of the Helina Valley.

Unit 2 of the Marie Creek Formation shows less textural variation with depth within a given testhole. Consequently the standard deviation about the mean texture value is generally low, less than 4% in most places (Table 7). One exception is the east part of the map area along the southern margin of the Marguerite Lake and Medley River Uplands. Here, the texture of unit 2 becomes significantly more sandy with depth (Appendix A, testhole T-27 and Figure 29, testhole T-32). A number of sources are offered to explain the increase in sand. In section SRA-200, situated along the Marie Creek, stratified lenses of sand are interbedded with the diamiction. In most places the lenses are nearly horizontal (Plate 4a), and appear to have been deposited synchronously with the diamicton. These may represent intrabeds of basal melt-out sand lenses, similar to those documented by Shaw (1982) in the Edmonton area. A melt-out origin of the Marie Creek till in this area is also supported by two other lines of evidence. The first is the concentration of boulders-

Smoothed Rose Diagram

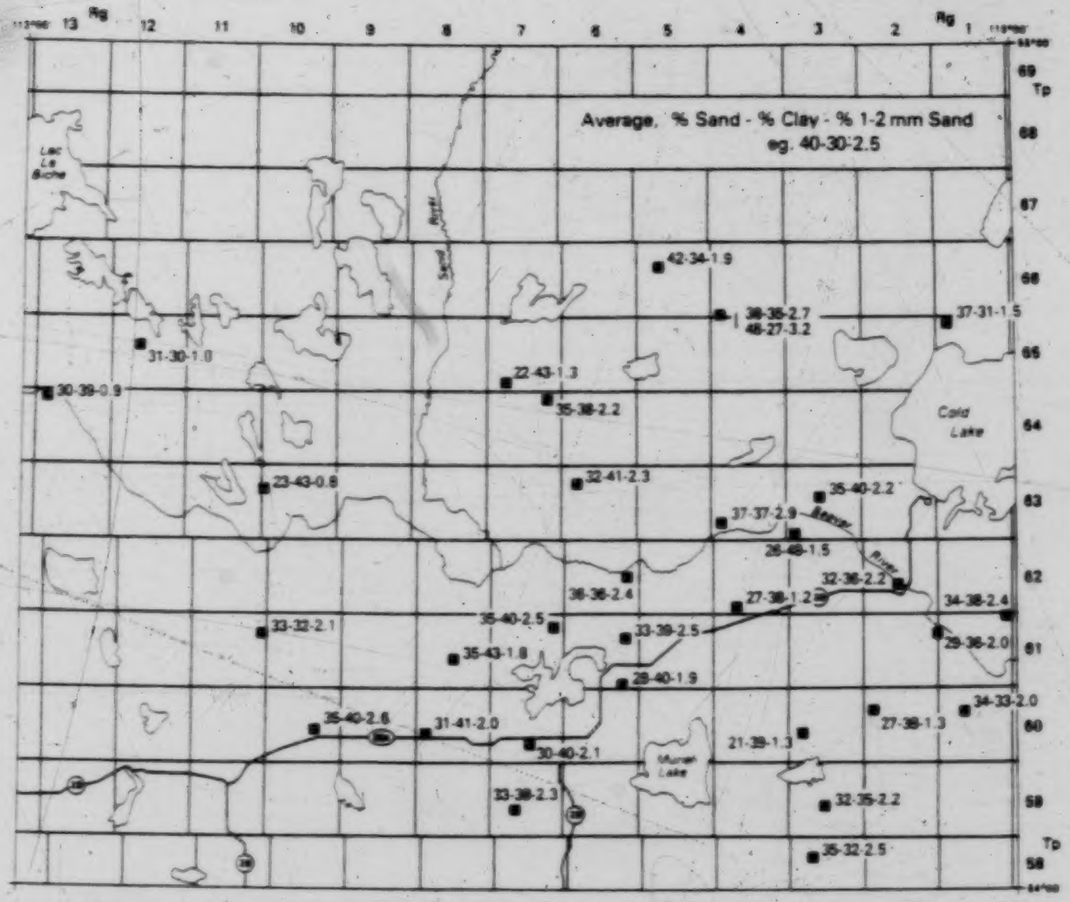
Section LA 81-2 LSD 3 Sec 18 Tp 63 Rg 2 W4M



K (smoothing factor) = 90

N (number of measurements) = 100

Figure: 38 Pebble orientations in the diamicton of unit 2 of the Marie Creek Formation.


Rg
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Rg
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Tp
69
68
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63
62
61
60
59
Tp
58
Average, % Sand - % Clay - % 1-2 mm Sand
eg. 40-30-2.5
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
42-34-1.9
38-38-2.7
48-27-3.2
37-31-1.5
31-30-1.0
22-43-1.3
30-39-0.9
35-38-2.2
23-43-0.8
32-41-2.3
35-40-2.2
37-37-2.9
28-48-1.5
38-38-2.4
32-38-2.2
27-38-1.2
34-38-2.4
33-32-2.1
35-40-2.5
33-39-2.5
29-38-2.0
35-43-1.8
28-40-1.9
34-33-2.0
35-40-2.6
31-41-2.0
27-38-1.3
21-39-1.3
30-40-2.1
33-38-2.3
32-35-2.2
35-32-2.5

Figure:39 Regional variations in the textural properties of unit 1 of the Marie Creek Formation.

within the till at outcrop SRA-200 (Plate 3b), which suggests preservation of discrete debris bands in the glacier by a slow melt-out depositional process. The second consists of the strong preferred pebble fabric at section LA 81-2 (Figure 38) which is interpreted to represent a preferred englacial orientation, preserved by a melt-out depositional process (Lawson 1979, Shaw 1982).

Other sand lenses in are irregularily shaped however and show evidence of deformation (Plate 4b). This deformation can indicate any one of numerous possibilities: in situ collapse deformation at the base of the glacier during basal melt-out, folding produced by resedimentation of diamiction and stratified sediment at the surface of an ablating glacier or, folding resulting from glacial plucking and incorporation of underlying glacial stratified sediment. Taking the last explanation, glacial erosion and incorporation of underlying local stratified sediment may account for the increase in the sand content of the matrix as well.

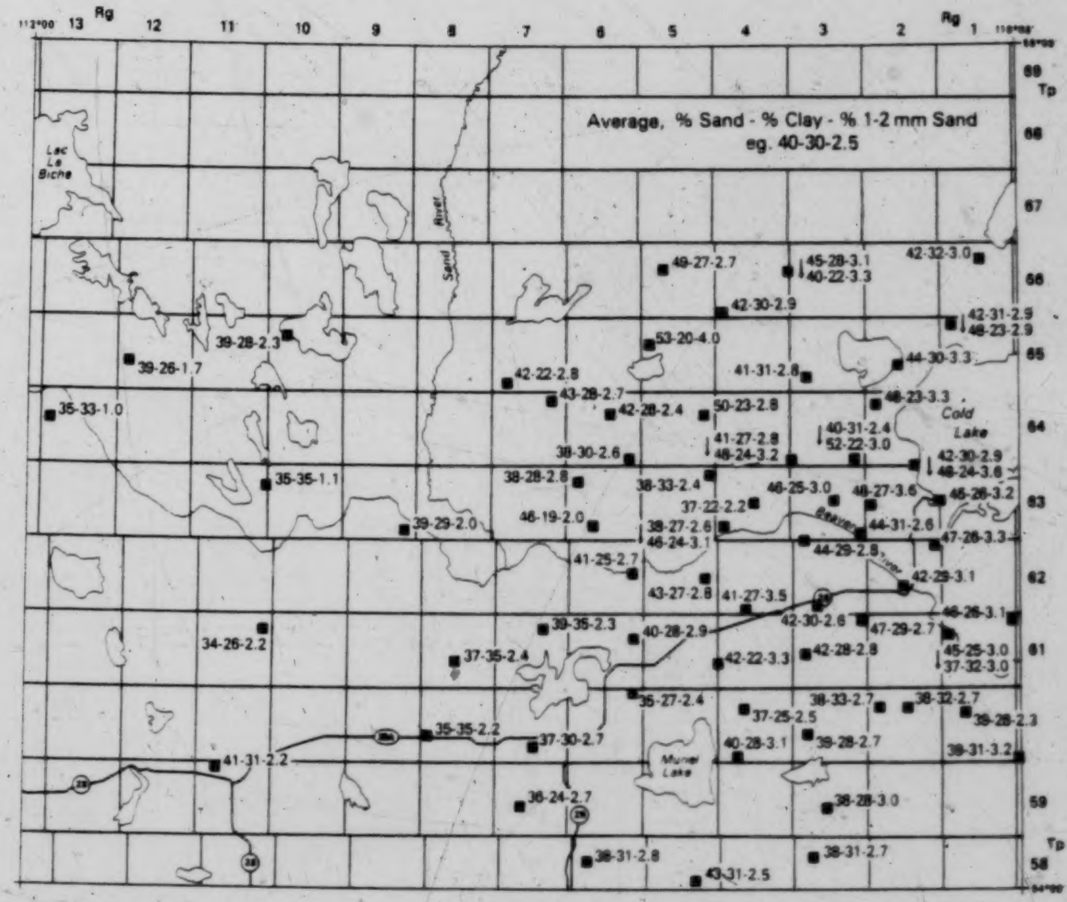
It is believed that glacial erosion and incorporation of the underlying unit 2 of the Bonnyville Formation can also account for the increased sand content of the base of the Marie Creek Formation. The evidence for this lies in the nature of the variations in the composition ot the very coarse sand fraction of the Marie Creek Formation. Table 7 show that the within-hole variations in the very coarse sand composition of unit 2 almost always show an apparent decrease in the amount of dolostone with depth. This decrease is gradual in places; abrupt in others. Conversely, the amount of quartz shows an apparent increase with depth. This change with depth in the carbonate-quartz content of the very coarse sand fraction represents both a slight decrease in the actual amount of carbonates, and a slight increase in the actual amount of quartz. The combination of the two produces a significantly lower carbonate to quartz ratio at the base of the Marie Creek Formation. This is demonstrated in Appendix C, in which normalized carbonate (percent carbonate calculated with the exclusion of quartz) is compared to normalized quartz (percent quartz calculated with the exclusion of carbonates) at both the top and bottom of the unit. The results of that comparison reveal that the Marie Creek Formation not only contains less carbonate with depth, but what carbonate is present, is also diluted by the addition of quartz. It seems likely that incorporation of the Bonnyville Formation is a logical explanation for these variations of the properties of unit 2 of the Marie Creek Formation.

In places incorporation of the Bonnyville Formation is reflected in both the texture and very coarse sand composition (Appendix A, testholes T-32 and T-44); in other places it is reflected in only the very coarse sand composition. For example, the very coarse sand composition of unit 1 of the Marie Creek Formation in testholes T-15, T-25, and T-43 (Appendix A), is gradational with the Bonnyville Formation, showing a decrease in carbonates and increase in quartz, whereas the texture becomes increasingly more clayey, rather than more sandy, near the contact.

In not all cases however, does the decrease in carbonates with depth, need to be attributed to the incorporation of the Bonnyville Formation. It is possible that a higher and lower carbonate facies were present in the glacier as the Marie Creek Formation was being deposited. The high carbonate facies of the formation, could in fact represent far-travelled material in the glacier (DiLabio 1981). Presumably, after the carbonates were eroded from the exposed outcrop in northeast Alberta, they were carried upward into the glacier and insulated from the abrasion, and comminution that was occurring at the base of the glacier. On the other hand, comminution at the base of the glacier could have eroded the carbonates, and produced a lower carbonate facies in the very coarse sand fraction. Thus, the high carbonate facies at the top of the Marie Creek Formation may reflect deposition by the ablation process, that is, the melt-out of englacial debris, whereas the low carbonate facies at the base of the formation may reflect deposition by either the lodgment process, or by basal melt-out of ice containing locally derived debris (Lawson, 1979, DiLabio, 1981).

Regional textural variations of unit 2 show a general decrease in sand and increase in silt and clay toward the west part of the map area (Figure 40). This likely reflects incorporation of the underlying units which, in the west are also more clayey. It is interesting to note however that, except for the extreme west part of the map area, the amount of coarse sand in the matrix of the Marie Creek Formation remains relatively high even though the overall texture of the unit becomes more clayey (Tables 6 and 7).

Regional variations in the very coarse sand composition of the Marie Creek Formation show that the high dolostone facies of unit 2 can be traced into the southwest part of the map area, but is absent in the west and northwest. It is probable that the high dolostone facies was present at one time, but was glacially eroded. The evidence for this



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63
62
61
59
Tp
58
54°00'
Average, % Sand - % Clay - % 1-2 mm Sand
eg. 40-30-2.5
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
49-27-2.7
45-28-3.1
40-22-3.3
42-32-3.0
42-30-2.9
42-31-2.9
48-23-2.9
39-28-2.3
39-26-1.7
53-20-4.0
41-31-2.8
44-30-3.3
42-22-2.8
43-28-2.7
48-23-3.3
35-33-1.0
42-28-2.4
50-23-2.8
40-31-2.4
52-22-3.0
41-27-2.8
48-24-3.2
38-30-2.6
42-30-2.9
48-24-3.6
35-35-1.1
38-28-2.8
38-33-2.4
46-25-3.0
48-27-3.6
45-28-3.2
37-22-2.2
46-19-2.0
39-29-2.0
38-27-2.6
46-24-3.1
44-31-2.6
44-29-2.8
47-28-3.3
41-25-2.7
42-29-3.1
43-27-2.8
41-27-3.5
46-26-3.1
42-30-2.6
34-26-2.2
39-35-2.3
40-28-2.9
47-29-2.7
45-25-3.0
37-32-3.0
37-35-2.4
42-22-3.3
42-28-2.8
35-27-2.4
38-33-2.7
38-32-2.7
39-28-2.3
37-25-2.5
35-35-2.2
37-30-2.7
40-28-3.1
39-28-2.7
39-31-3.2
41-31-2.2
38-24-2.7
38-28-3.0
38-31-2.8
38-31-2.7
43-31-2.5
28
28
28
28

Figure: 40 Regional variations in the textural properties of unit 2 of the Marie Creek Formation. Note the gradual decrease westward in the amount of sand.

consists of thick, displaced masses of the high dolostone facies which are contained within the Vilna Member of the overlying Grand Centre Formation (Appendix A, testhole 77SR-22).

The stratigraphic evidence, though not conclusive, suggests that the Ardmore Glacier likely halted along an ice-marginal position in the southwest. The evidence consists of the coincidental margins of the western extents of both the underlying Ethel Lake Formation and the Marie Creek Formation (Figures 30 and 35). The thick sequences of silt, clay, sand and gravel of the Ethel Lake Formation along this western trend, likely were deposited in a kame-delta environment along the glacier margin. As well, the glacier remained stable long enough to deposit thick till of the Marie Creek Formation, as shown in Figure 37.

The extent of the Ardmore Glacier is uncertain, primarily because the Marie Creek Formation does not extend throughout the entire the map area (Figure 37). Two interpretations are offered to explain the absence of the formation in the southwest. Firstly, it is possible that the the Ardmore Glacier terminated its advance against the northeast slope of the underlying bedrock topography in the southwest, extending as a small lobe only in the lowland above the buried Beverly Valley in Tps 58-59, Rgs 9-10 (Figure 35, and Figure 58, testhole 77SR-7). Presumably, along this terminal moraine, both thick stratified deposits of the Ethel Lake Formation, and thick till of the Marie Creek Formation, were deposited (Figures 31 and 37). Possibly, the Marie Creek till was deposited from an southeast flowing ice-stream (Dyke 1984) which did not extend any further southwest than defined by the distribution of the till (Figure 35). As shown in the following chapter of the Grand Centre Formation, a southeast flowing ice-stream for the Marie Creek till is coincidental with the much later Lac LaBiche Lobe which deposited the uppermost till of the Grand Centre Formation.

A second explanation for the absence of the formation in the southwest is that it was once extensive throughout the entire map area, but was subsequently eroded shortly after deposition. Two lines of evidence support this interpretation. Firstly, a buried, carbonate rich till in the Cooking Lake Moraine, east of Edmonton (Andriashek, 1981) correlates with the Marie Creek Formation in the Sand River map area. If it is the same till as the Marie Creek Formation and, we assume that the Ardmore Glacier advanced from the north, or slightly west of north, as the pebble fabric in the east suggests, then it indicates the Ardmore Glacier did extend south and west of the Sand River Map area. It follows then that the Marie Creek Formation likely was deposited in the southwest corner of the Sand River area as well. Thus, erosion seems to be the most likely explanation for the absence of the Marie Creek Formation in the southwest. The second line of evidence, though more circumstantial, is the presence of the extensive, highly oxidized profile on the surface of the Bonnyville Formation in the southwest. This highly oxidized profile is recognized primarily in those areas where the Marie Creek Formation is absent. One implication of this is that in the southwest the surface of the Bonnyville Formation was exposed to more than one weathering event to account for the greater degree and well preserved nature of oxidation. As previously discussed, the first weathering event which the surface of the Bonnyville Formation was exposed to, occurred during the nonglacial period following the retreat of the Fort Kent Glacier. The second weathering event presumably occurred during the nonglacial period which followed the retreat of the Ardmore Glacier. Two weathering events on the surface of the Bonnyville Formation could have occurred only if the formation was not buried by till of the Marie Creek Formation. This implies that, if the Marie Creek till was deposited in the southwest, and the evidence in the Cooking Lake area supports this then, the till must have been eroded shortly after it was deposited, prior to the major weathering period which followed.

Erosion of the surface of the Marie Creek Formation by glacial meltwater is indicated in two places. In one case, an erosional channel is present above the underlying buried Beverly Valley in Tps 59 to 60, Rgs 6 to 9 (Figure 35). In the second case, fluvial erosion is suggested by the relatively thin deposits of the formation which lie in two linear trends in the Beaver River Lowland Plains (Figure 37). This period of erosion likely occurred during, or shortly after the retreat of the Ardmore Glacier, because the top of the formation in these eroded areas is oxidized, indicating that it was exposed during the nonglacial weathering period which followed.

For the most part, erosion during the nonglacial period was relatively minor, as evidenced by the widespread preservation of the oxidized profile on the surface of the Marie Creek Formation. Furthermore, leaching of the top of the formation was not significant, as indicated by the relatively high carbonate content (in both the sand and silt-clay fractions) in the upper oxidized part of the till.

X. SAND RIVER FORMATION

Source of name: Sand River located in the central part of the Sand River map area NTS 73 L.

Type section: Alberta Geological Survey auger testhole T-9, located along the Beaver River in LSD 13, Sec 10, Tp 62, Rg 2, W4M in the east part of the Sand River map area NTS 73 L (Figure 32).

Type area: The area adjacent to the Beaver River in the east part of the Sand River map area, NTS 73 L.

Reference sections: Exposed road cut on the west side of Hwy.28 on the south side of the Beaver River crossing in LSD 14, Sec 10, Tp 62, Rg 2, W4M; Alberta Geological Survey auger testholes T-6 (LSD 15, Sec 31, Tp 62, Rg 3, W4M), T-14 (LSD 4, Sec 17, Tp 60, Rg 3, W4M); Alberta Environment testholes E802 (LSD 5, Sec 32, Tp 61, Rg 5, W4M), E804 (LSD 4, Sec 1, Tp 64, Rg 4 W4M).

A. Description of Unit

The Sand River Formation consists of stratified sand and silt with lesser amounts of clay and gravel. The formation is recognized in outcrops and testholes primarily in the central and southwest parts of the map area. Dry-auger samples indicate that the top of the formation is oxidized in the subsurface but becomes unoxidized dark grey (5Y 4 / 1) with depth. In places the formation is oxidized at the top and bottom, but unoxidized in between (Appendix A, testholes T-18, T-45, T-72).

Sand and silt are commonly oxidized olive brown (2.5Y 4 / 4) in outcrops. The sand is generally fine to medium grained, well sorted, and commonly clast free. The composition of the sand was not examined in detail, but field observations describe the lithic composition as consisting primarily of quartz with lesser amounts of igneous, metamorphic and locally derived rock fragments. Commonly the sand is stratified, with cross-bedding visible in outcrop. Testhole observations indicate that in many places the sand is interbedded with silt. Locally, lenses of massive diamicton are also present.

Finer deposits, consisting of silt, and interbedded silt and clay, are not common, and have only a limited extent. Dry-auger flite samples show that whereas the clay is finely bedded with silt laminae, the silt is more massive. In places thin lenses of diamicton are interbedded with the silt and clay.

All deposits of the Sand River Formation are generally poorly consolidated, soft, moist and easy to penetrate with a dry auger.

Distribution, Thickness, and Subcrop Topography

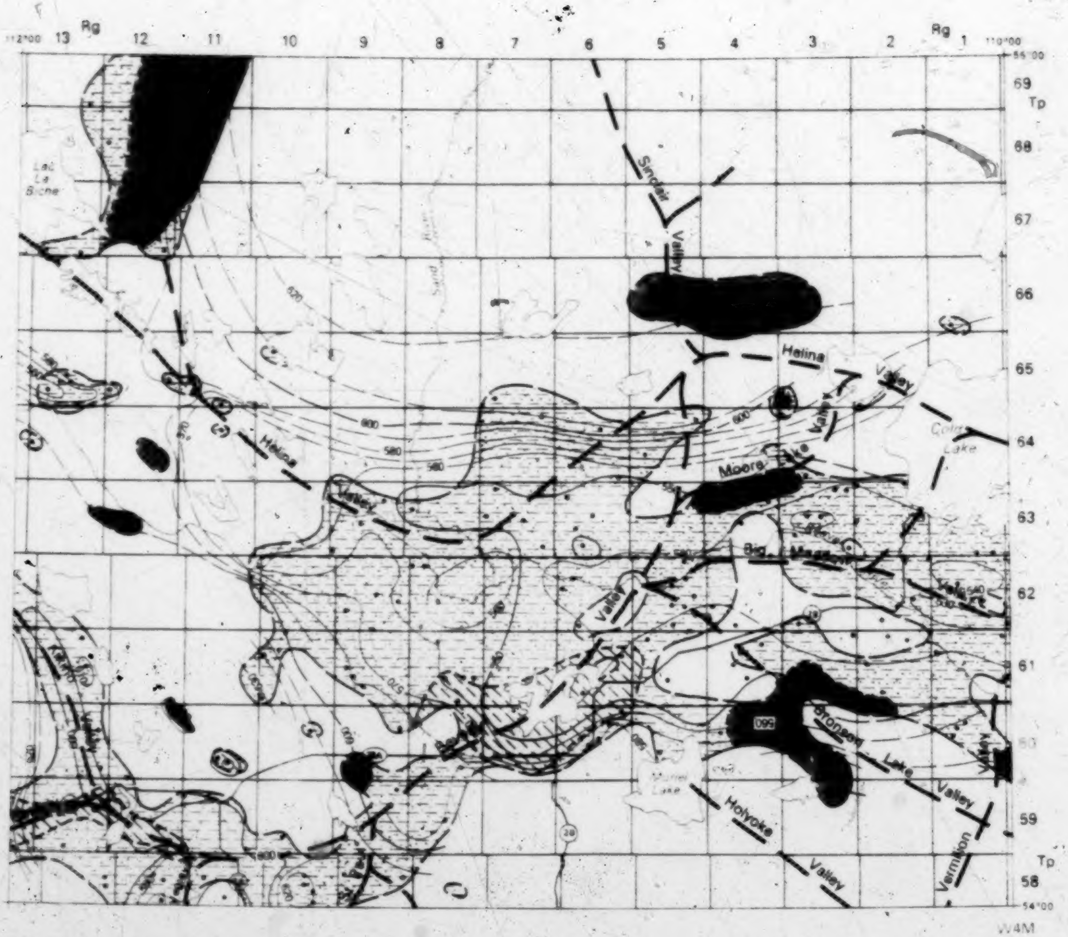
The Sand River Formation lies mainly in the central and southwest parts of the map area (Figure 41). It is either absent or thin and discontinuous within the most of the uplands.

The top of the formation ranges in elevation from as high as 620 m in Tp 59, Rg 14 in the Vilna Plains, to as low as 530 m in Tp 62, Rg 1 within the Beaver River Lowland Plain (Figure 41).

Figures 41 and 42 show that silt and sand of the Sand River Formation form a thin, relatively continuous veneer over much of the Marie Creek Formation within the Beaver River Lowland Plain. Along the southern margin of the Beaver River Lowland Plain, the formation consists of silt and clay, locally mantled by sand. These finer deposits are thick along this margin, particularliy in the area west of Angling Lake in Tps 60-61, Rgs 3-4, where 18 m of clay, silt and sand are mapped (Figure 8, x-sec E1-E1' and Figure 9, x-sec N1-N1'). Thick deposits of the Sand River Formation also appear to infill a depression on the surface of the Marie Creek Formation in Tp 63, Rgs 5-7 (Figures 35 and 42).

The Sand River Formation is less extensive in the southwest and northwest corners of the map area, where it overlies the Bonnyville Formation. Within the Vilna Plain, in Tps 58-59, Rgs 12-13, the formation lies in a narrow, erosional valley on the surface of the Bonnyville Formation. Thick deposits of silt and clay lie within the base of this valley. These in turn are overlain by sand and gravelly which extend out of the valley, and across a broad depression on the surface of the Bonnyville Formation above the buried Kikino Valley (Figures 9, x-sec E4-E4', and 41).

In the northwest, in Tps 67-69, Rgs 11-13 the Sand River Formation consists mainly of thin silt and clay which drape the gently west-sloping Bonnyville Formation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63
62
61
60
59
58
Tp
W4M
Lac La Biche
Sinclair Valley
Helina Valley
Moore Lake
Cold Lake
Big Meadow
Valley
Bronson Lake Valley
Holyoke Valley
Vermilion
Muriel Lake
600
580
560

Figure: 41 Elevation of the upper surface of the Sand River Formation.

Note the extensive distribution of the formation above the buried Imperial Mills, Kikino and Beverly Valleys.

■ Silt and Clay

▤ Sand and Silt

▨ Clay, Silt, Sand and Gravel

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - -

Contours, Interval 10 metres:

Defined 500

Approximate 500

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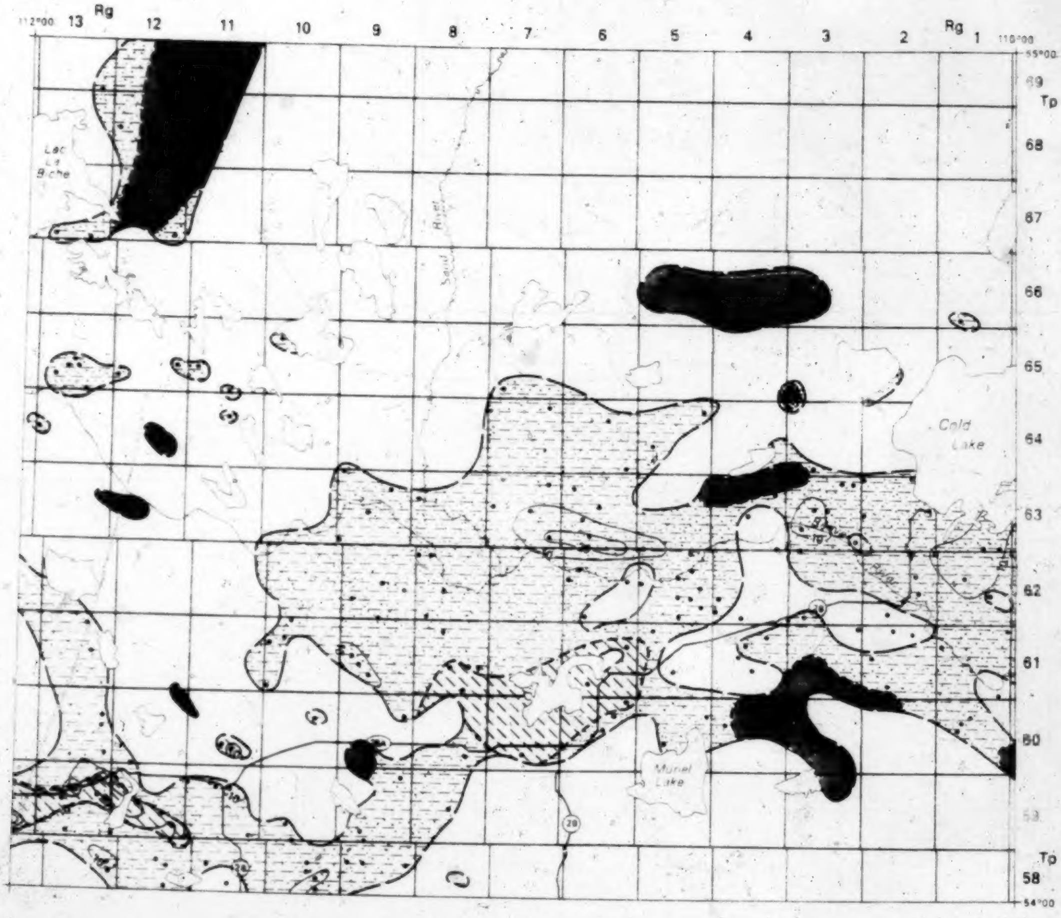
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64
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62
61
60
59
Tp
58
54°00
W4M
Lac La Biche
Sand River
Cold Lake
Muriel Lake

Figure: 42 Thickness of clay, silt, sand and gravel in the Sand River Formation.
Note the extensive, thin deposits in the central part of the map area.

■ Silt and Clay

▒ Sand and Silt

▨ Clay, Silt, Sand and Gravel

Unit Boundaries:
Approximate ....
Assumed ....
Isopach, Interval 10 metres 50
Data Location .... •

(Figures 26 and 42). Small, discontinuous deposits of the formation are also recognized within the Lac LaBiche and Seibert Lake Uplands.

Differentiation from other units

There are no distinctive lithologic or compositional properties which differentiate deposits of the Sand River Formation from stratified deposits of any of the other formations. Consequently, the Sand River Formation is differentiated and correlated primarily by stratigraphic position. The Sand River Formation is differentiated from the underlying Ethel Lake Formation with certainty only in those places where the Marie Creek Formation separates the two. Thus, the two formations cannot be easily differentiated in the southwest and northwest parts of the map area where the Marie Creek Formation is absent and where stratified sediments of both formations overlie the Bonnyville Formation. For purposes of classification however, in this setting all of the stratified deposits which overlie the Bonnyville Formation, are considered to be as young as possible and are included within the Sand River Formation.

Nature of Contacts

Lower Contact

In most places the Sand River Formation has a sharp contact with the top of the underlying Marie Creek or Bonnyville Formations (Figure 5, testholes E761, E802, and E804). The contact is considered to be conformable in those places where oxidized deposits of the Sand River Formation overlie oxidized till of the Marie Creek Formation (Appendix A, testhole T-18). Conversely, the contact is disconformable in those areas where unoxidized deposits of the Sand River Formation overlie oxidized till of either the Marie Creek Formation (Appendix A, testhole T-7) or the Bonnyville Formation (Appendix A, testhole 77SR-15). In some places the oxidized, high dolostone facies of the upper part of the Marie Creek Formation has been eroded prior to burial by the Sand River Formation, suggesting that the contact is unconformable (Appendix A, testhole T-27).

In a few locations contacts, based on oxidized profiles, are recognized within the Sand River Formation itself. For example, in testholes T-18, T-45, T-72 and 77SR-17 (Appendix A), the Sand River Formation consists of unoxidized sand which overlies oxidized silt and clay. This implies that a period of weathering occurred after the deposition of the clay and prior to the depositon of the sand. These contacts are considered to be disconformable, and likely represent more than one depositional event.

Contact

The upper contact of the Sand River Formation with the base of the overlying Grand Centre Formation can be sharp or gradational. For example, the contact is sharp and considered to be disconformable in those places where unoxidized deposits of the Grand Centre Formation overlie oxidized sand of the Sand River Formation (Figure 32). Conversely, the contact is considered to be gradational and conformable where the upper part of the Sand River Formation consists of interbedded sand and diamicton which is lithologically similar to the base of the overlying Grand Centre Formation (Appendix A, testholes T-6 and T-27).

Origin

The origin of the stratified sediment of the Sand River Formation is uncertain. It is considered that not all of the deposits have the same genesis, nor were they deposited during the same event. Some of the stratified deposits, particularily the silt and clay, were probably deposited during the retreat of the Ardmore Glacier. It is uncertain if these fine sediments have a glaciolacustrine origin, deposited in proglacial lakes, or a glaciofluvial origin, representing overbank sediment. Certainly, Figure 42 shows that these fine deposits have a limited extent, except for above the buried Imperial Mills Valley, which does not support a widespread, lacustrine setting. The evidence that these sediments were deposited during the retreat of the Ardmore Glacier consists of an oxidized horizon which, in places, pervades through the surface of the sand and clay of the Sand River Formation, down into the till of the underlying Marie Creek Formation (Appendix A, testholes T-23 and 77SR-23). This oxidized horizon indicates that the stratified sediment was deposited immediately after the till and that both were subject to the same weathering interval. In testhole T-9 (Figure 32) these stratified deposits were sufficiently thick to prevent the oxidation from pervading into the underlying till of the Marie Creek Formation.

The coarser-grained silt and sand, which form a widespread veneer throughout the central part of the map area, likely have either a glaciofluvial or glaciolacustrine origin. On one hand, the widespread abundance of fine-grained sand and silt, interbedded with thin diamicton layers in places, suggests a glaciolacustrine origin (Figure 42). On the other hand, the presence of gravel beds and large scale cross-bedding in places, suggests a glaciofluvial origin, though, these could represent beach deposits associated with a glacial lake.

It is considered that the bulk of the sand of the Sand River Formation was deposited during the advance phase of the Cold Lake Glacier, rather than the retreat phase of the Ardmore Glacier. The evidence for this consists of widespread unoxidized sand which overlies oxidized silt and clay of the Sand River Formation (Appendix A, testhole 77SR-17) and, oxidized till of the Marie Creek and Bonnyville Formations (Appendix A, testholes T-6 and T-7, 77SR-15, 77SR-27, 77SR-28, and 77SR-29). The fact that unoxidized sand overlies oxidized, older units, likely indicates that the sand was not exposed or weathered for any significant period, but that it was buried immediately by glacial sediment of the Cold Lake Glacier.

In places the meltwater which deposited the sand of the Sand River Formation, also eroded the surface of the underlying Marie Creek Formation. In testholes T-27 and T-36 (Appendix A), for example, the upper oxidized, high carbonate facies of the Marie Creek till was eroded.

XI. GRAND CENTRE FORMATION

Source of Name: The town of Grand Centre, Alberta located in Tp 63, Rg 2, W4M in the east part of the Sand River map area, NTS 73L.

Type Section: The Grand Centre Formation consists of four members, each of which have a designated type section. These members are:

Hilda Lake Member - Type Section: Section LA81-1, exposed road cut along the west bank of the Marie Creek in Sec. 30, Tp 63, Rg 2 W4M in the Sand River map area, NTS 73L. At this location the Hilda Lake Member overlies the Marie Creek Formation and is overlain by the Reita Lake Member of the Grand Centre Formation.

Reita Lake Member - Type Section: Section LA81-1, exposed road cut along the west bank of the Marie Creek in Sec. 30, Tp 63, Rg 2 W4M, in the Sand River map area NTS 73L. At this location the Reita Lake Member overlies the Hilda Lake Member of the Grand Centre Formation, and is exposed at the surface.

Kehiwin Lake Member - Type Section: Alberta Geological Survey auger testhole 77SR-17, located in LSD 15, sec. 9, Tp 61, Rg 8, W4M in the Sand River map area, NTS 73L. At this location the Kehiwin Lake Member overlies the Reita Lake Member, and is exposed at the surface.

Vilna Member - Type Section: Alberta Geological Survey auger testhole 77SR-7, located in LSD 16, Sec 29, Tp 59, Rg 11, W4M in the Sand River map area, NTS 73L. At this location the Vilna member overlies the Kehiwin Lake Member, and is exposed at the surface.

Type Area: There is no type area defined for the Grand Centre Formation as such. Rather, type areas have been defined for each of the members.

The type area for both the Hilda Lake and Reita Lake Members is in the eastern part of the map area, north and west of the town of Grand Centre. The type area for the Kehiwin Lake Member is in the central part of the map area near the town of Glendon. The type area for the Vilna Member lies between the towns of Ashmont and Mallaig in the southwest corner of the map area.

Reference Sections: The reference sections are given in the descriptions of each member.

Description of the formation

The Grand Centre Formation is the uppermost formation in the Quaternary sequence in the Sand River map area. It is widespread, and lies at the surface in most places, except where it is buried by postglacial stratified deposits (Figure 43 and Fenton and Andriashek, 1983). The formation is composed primarily of diamicton which generally is characterized by a sandy-clay matrix, a relative abundance of igneous and metamorphic fragments in the very coarse sand fraction, a soft, unconsolidated nature, and a dark grey-brown color.

The top of the Grand Centre Formation ranges in elevation from as high as 790 m in the Heart Lake and Muriel Lake Highlands, to less than 550 m in the Beaver River Lowland Plain (Figure 44). It forms one of the thickest stratigraphic units in the map area, ranging between 10 m and 30 m over most of its extent (Figure 45). Large areas of thick deposits of the Grand Centre Formation are mapped within the Kehiwin Upland Plains and, within the Vilna Plains and Saddle Lake Uplands. In places within these uplands the formation is as much as 60 m thick. Small areas of exceedingly thick deposits of the Grand Centre Formation are mapped within the isolated highlands which lie south of the larger lakes in the map area (Cold Lake, Marie Lake, Primrose Lake, Wolf Lake, Muriel Lake). In most of these highlands the Grand Centre Formation consists of ice-thrust, glacially displaced masses of older sediment, including diamicton which is not characteristic of the Grand Centre Formation. For example, within the Wolf Lake and Primrose Lake highlands the Grand Centre Formation consists of more than 60 m of ice-thrust Marie Creek till (Appendix A, testholes T-1, 77SR-33).

On the basis of differences in matrix texture, color, orientiation of glacial ice-flow indicators, and stratigraphic position, the Grand Centre Formation is divided into four members (Figure 43). From oldest to youngest, these are: the Hilda Lake Member, the Reita Lake Member, the Kehiwin Lake Member, and the Vilna Member. Detailed descriptions of each of these of members are given separately. The following is a summary of those descriptions.

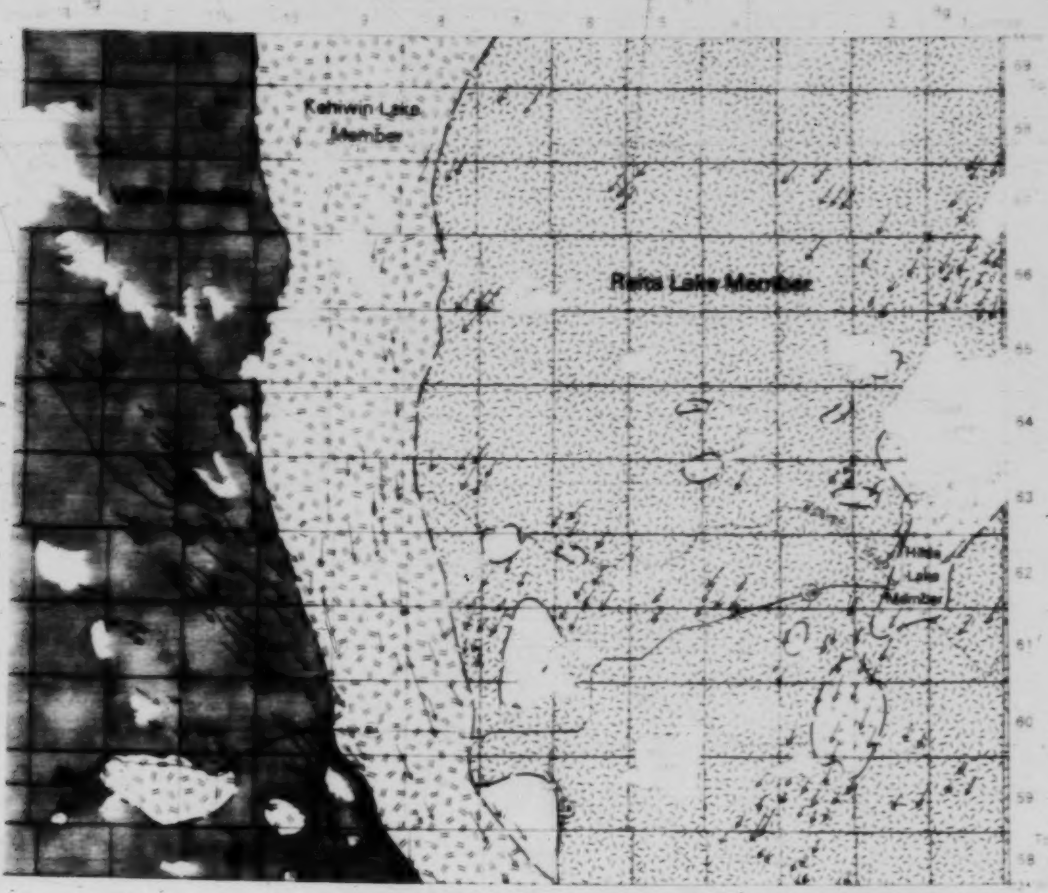

Kehiwin Lake Member
Reita Lake Member
Hilda Lake Member
69
68
67
66
65
64
63
62
61
60
59
58

Figure: 43 Outcrop map of the Hilda Lake, Reita Lake, Kehiwin Lake, and Vilna Members of the Grand Centre Formation. The figure also depicts the glacial flow directions of the Primrose Lobe, Seibert Lobe and Lac La Biche Lobe of the Cold Lake Glacier.

Vilna Member
Diamicton (till) and Displaced Sediment

Kehiwin Lake Member
Diamicton (till), Locally Overlain by Sand and Gravel

Reita Lake Member
Diamicton (till)

Hilda Lake Member
Diamicton (till) and Displaced Sediment

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -
Isopach, Interval 10 metres 50
Data Location .... •

Primrose Lobe .... ↙↙
Seibert Lobe .... ↓↓
Lac La Biche Lobe .... ↘↘

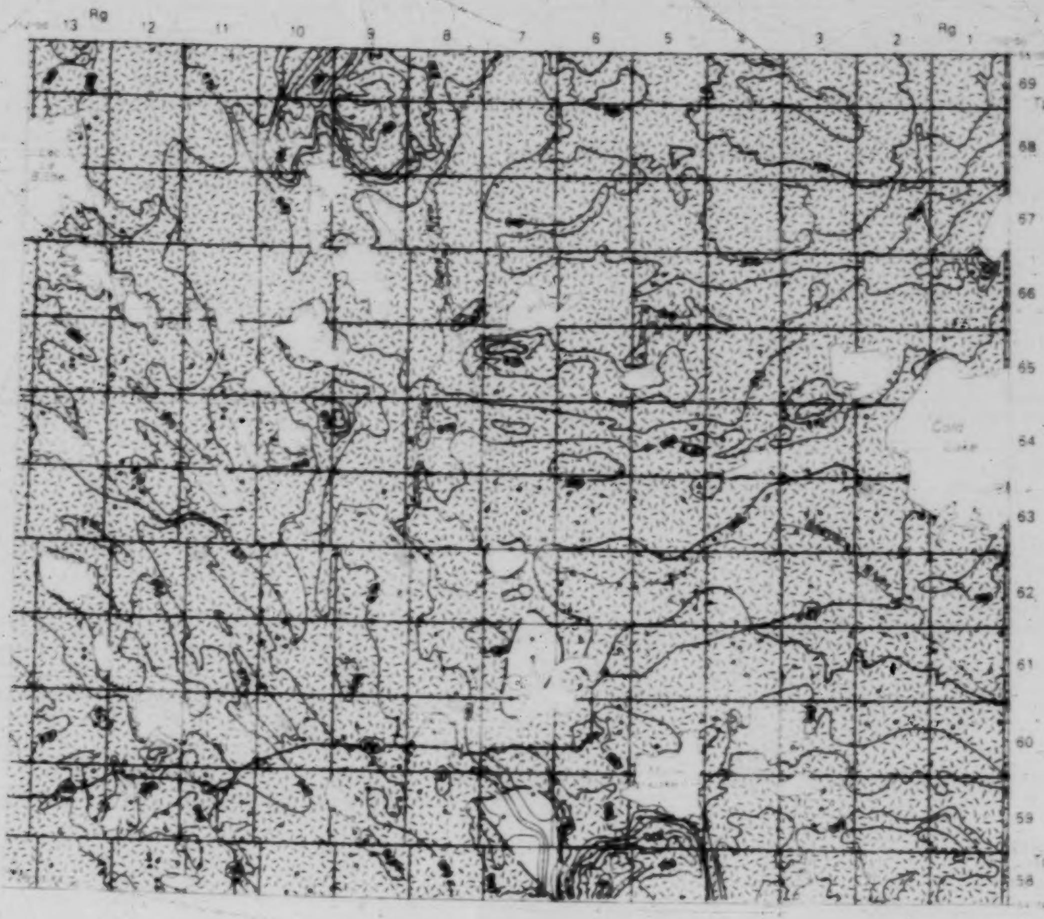

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Cold Lake

Figure 44 Elevation of the upper surface of the Grand Centre Formation.

Note the isolated, high relief features south of Primrose Lake, Marie Lake, Cold Lake, Wolf Lake, Pinehurst Lake and Muriel Lake.

▨ Diamicton

Unit Boundaries:
  Approximate .... — — —
  Assumed .... - - - - - - -
Contours, interval 30 metres:
  Defined .... ═══
  Approximate .... ═ ═ ═
Data Location .... •

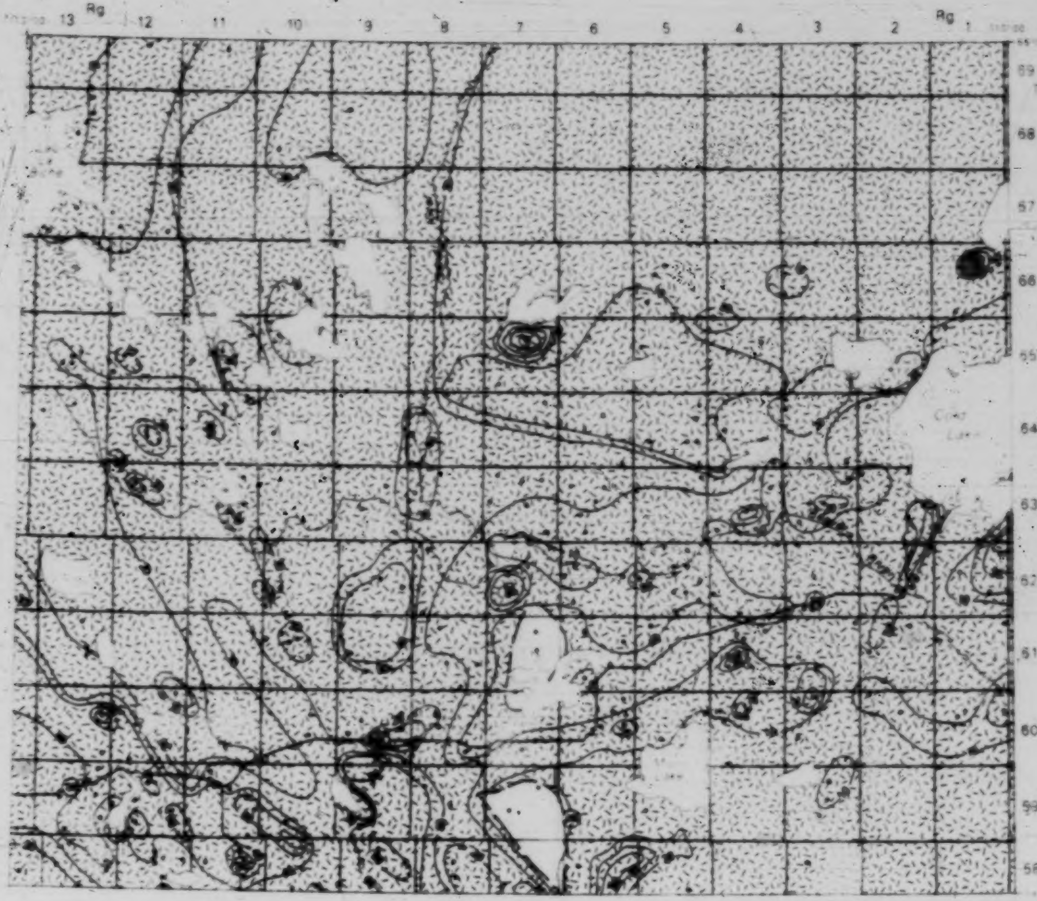

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Cold Lake

Figure:45 Total thickness of the Grand Centre Formation.

Note the very thick deposits directly south of Primrose Lake, Wolf Lake, Cold Lake, and Muriel Lake.

▨ Diamicton

Unit Boundaries:

Approximate .... — — —

Assumed .... - - - - -

Isopach, interval 10 metres .... ═ 50 ═

Data Location .... •

Hilda Lake Member

The Hilda Lake Member consists of a very dark grey-brown clayey diamicton, which locally contains incorporated masses of glacially displaced older sediment, including shale and ironstone. The member is confined primarily to the east-central part of the map area. In most places the member is overlain by diamicton of the Reita Lake Member, except south of Cold Lake where the Hilda Lake Member outcrops. Here, glacially streamlined landforms on the surface of the member characteristically have a northeast-southwest orientation. Commonly a boulder concentration can be found at the base of the unit.

Reita Lake Member

The Reita Lake Member consists of a dark grey-brown sandy-clay diamicton, which forms the surface unit over most of the east half of the Sand River map area (Figure 43). The member is characteristically soft and moist and has a massive to slightly fissile structure. It has relatively few pebbles or granules but in places a boulder concentration can be found at the base. Glacially streamlined features on the surface of the member also have a preferred northeast-southwest orientation, similar to that of the Hilda Lake Member. The Reita Lake Member is less clayey and has a lighter grey-brown color than the underlying Hilda Lake Member.

Kehiwin Lake Member

The Kehiwin Lake Member consists primarily of an olive-brown, sandy diamicton which outcrops in the central part of the map area (Figure 43). The diamicton contains relatively few pebbles or granules, and has a blocky, well jointed structure with visible iron staining along the joint surfaces. In the southwest corner of the map area the diamicton is overlain by stratified sediment. The Kehiwin Lake Member overlaps the Reita Lake Member along its eastern margin, and is overlapped by the Vilna Member along its western margin. Glacially streamlined features on the surface of the member have a preferred north-south orientation. The lighter, olive-brown color, sandier texture, and north-south orientation of glacial-flow indicators, differentiate the Kehiwin Lake Member from the Reita Lake Member.

Vilna Member

The Vilna Member consists of a very dark grey-brown, clayey diamicton which locally contains masses of glacially displaced, older sediment, including shale and siltstone. The diamicton contains relatively few pebbles or granules, though in places is composed almost entirely of rounded "clasts" of clay which have been derived from reworked shale. The Vilna Member forms the surface unit in the west part of the Sand River map area (Figure 43). Although it overlies the Kehiwin Lake Member in the southwest, the two have a gradational contact in the central part of the map area. Glacially streamlined landforms on the surface of the Vilna Member have a preferred northwest-southeast orientation, orthogonal to the orientation of the features on the surface of the Hilda Lake and Reita Lake Members. The very clayey texture, darker grey-brown color, and northwest-southeast orientiation of glacial-flow indicators differentiate the Vilna Member from the Kehiwin Lake Member.

Differentiation from other Units

The Grand Centre Formation is differentiated from other units on the basis of stratigraphic position, color, structure, texture, composition of the very coarse sand fraction, and electric log responses. The formation is the uppermost diamicton and overlies either stratified sediment of the Sand River Formation, or tills of the Marie Creek and Bonnyville Formations (Figure 9, x-sec N1-N1'). Diamicton of the four members of the Grand Centre Formation are differentiated from the underlying tills of the Marie Creek and Bonnyville Formations by the following:

1. With the exception of the Kehiwin Lake Member, all other members of the Grand Centre Formation have a darker, grey-brown oxidized color compared to the olive-brown oxidized color of the Marie Creek and Bonnyville Formations.
2. The Hilda Lake, Reita Lake, and Vilna Members are generally massive to slightly fissile, moist and soft compared to the Marie Creek Formation which is jointed, consolidated and relatively dry. The Kehiwin Lake Member may be as jointed, but is soft and unconsolidated.
3. The Hilda Lake, Reita Lake, and Vilna Members are less sandy, particularily in the

amount of very coarse sand, and more clayey than either the Marie Creek Formation or the Bonnyville Formation in the eastern two-thirds of the map area (Table 2). In the western part of the map area the texture of the Vilna Member and the Bonnyville Formation are not too dissimilar. The Kehiwin Lake Member is similar in texture to both the Marie Creek and Bonnyville Formations but does not contain nearly as much very coarse sand (Table 2).

4. All members of the Grand Centre Formation contain more igneous and metamorphic fragments in the very coarse sand fraction, than either the Marie Creek or Bonnyville Formations. As well, they contain much less quartz than the Bonnyville Formation, and significantly less carbonate than the upper part of unit 2 of the Marie Creek Formation (Table 2). One exception is the Kehiwin Lake Member; it may also have as much quartz as the Bonnyville Formation.
5. All members of the Grand Centre Formation have a lower resistivity response than the top of the Marie Creek Formation. In the east half of the map area the resistivity responses of the Grand Centre Formation are also lower than that of the Bonnyville Formation, but the reverse is true in the west where, in places the Bonnyville Formation is more clayey, and has a lower resistivity.

The areas of difficulty in differentiating the Grand Centre Formation from the other units are where significant amounts of glacially displaced blocks of older sediment, especially glacial sediment, are incorporated into the formation. This occurs within many of the highland physiographic units in the map area.

Nature of Contacts

The nature of the contacts of the four members of the Grand Centre Formation is discussed in detail further under their respective sections. A summary is provided here.

The contact of the Grand Centre Formation with the stratified sediments of the underlying Sand River Formation is generally sharp. The contact is considered to be disconformable for the most part, though in places a conformable contact is recognized where the upper part of the Sand River Formation appears to have been deposited immediately prior to the deposition of the diamicton of the Grand Centre Formation.

The contact of the Grand Centre Formation with the top of the Marie Creek Formation is disconformable and, in most places, sharp. The sharp contact is evident in those outcrops and testholes where unoxidized diamicton of the Grand Centre Formation overlies oxidized diamicton of the Marie Creek Formation. In places a boulder concentration lies along this contact. Erosional contacts are recognized where the top of the Marie Creek Formation has been incorporated into the base of the Grand Centre Formation by glacial ice-thrusting. However, the nature of erosion and incorporation is generally in the form of large, discrete masses rather than as a gradational reworking and dissemination of the underlying Marie Creek Formation.

In the southwestern part of the map area, where the Grand Centre Formation directly overlies the Bonnyville Formation in many places, the contact is generally sharp and easily recognized on the electric log responses (Figure 9, x-sec E4-E4', testhole E496). The presence of a buried oxidized horizon at the surface of the Bonnyville Formation indicates that this contact is disconformable.

The contacts between the various members are discussed in detail in the following sections of this report. The upper surface of the Grand Centre Formation is exposed except where covered by postglacial stratified sediment.

Origin

The diamictons of the four members of the Grand Centre Formation represent glacial sediment which was deposited during the last major glaciation in the map area, the Cold Lake Glaciation. The distribution and extent of the Grand Centre Formation indicates that this glaciation covered the entire map area and extended west and south of the region.

The advance of the glacier involved three lobes: the first, the Primrose Lobe, advanced from the northeast, the next, the Seibert Lobe, advanced from the north, and the last, the Lac LaBiche Lobe, advanced from the northwest (Figure 43). The Hilda Lake and Reita Lake Members were deposited by the Primrose Lobe, the Kehiwin Lake Member by the Seibert Lobe, and the Vilna Member by the Lac LaBiche Lobe.

Glacial thrusting was associatied with all three lobes. In fact, all of the highland physiographic units owe their origin, in part, to glacial thrusting by these lobes. This thrusting and incorporation of large masses of the underlying stratigraphic units accounts for the diverse lithology of both the Hilda Lake and Vilna Members. On the basis of the type of displaced sediment found within these highlands, it is apparent that the depth at which the failure occurred during the glacial thrusting, was controlled by specific subsurface units. The predominance of till of the Marie Creek Formation within the Wolf Lake, Primrose Lake and Marie Lake Highlands indicates that the effects of the thrusting extended to the base, or even below, the Marie Creek Formation. Possibly this failure occurred within the stratified silt and clay of the underlying Ethel Lake Formation or, even deeper, within shale of the Lea Park Formation. Certainly, the abundance of ice-thrust shale in the Hilda Lake Member south of Cold Lake indicates that the depth of thrusting extended at least as deep as the Lea Park Formation. Likely here, the Primrose Lobe Lobe eroded the shale which outcropped or subcropped along the south bank of the buried Helina valley.

The enrichment of the base of the Primrose Lobe with clay from the reworked shale, resulted in a very clayey basal component of the till which was deposited from that lobe. It is believed that this is the origin of the very clayey till of the Hilda Lake Member. It is likely that higher up within the Primrose Lobe, less shale would have been incorporated and thus, the upper part of the till would be also be less clayey. It is believed that the till of the Reita Lake Member represents this upper, less clayey facies.

Glacial thrusting and incorporation of the underlying stratigraphic units, also accounts for the varied lithology of the Vilna Member. During the advance of the Lac LaBiche Lobe, much of the underlying shale and siltstone of the Belly River Formation was displaced and incorporated into the glacier. In some outcrops near the thrust zone, the glacier deposited large, intact blocks of the bedrock material. Farther down-ice from the source, these large blocks underwent glacial comminution, and were deposited as a till, composed almost entirely of rounded "clasts" of reworked shale.

The origin of the sandy till of the Kehiwin Lake Member is less certain. Shallow outcrops show that in many places the member is composed of sandy till with numerous lenses or beds of stratified sand. It is uncertain if these lenses were deposited in situ, by basal meltout (Shaw, 1982), or if they represent eroded "clasts" of underlying stratifed sediment. Certainly to the north, in the Seibert Lake Touchwood Lake area, glacial thrust landforms are present, indicating that the northern part of the member is likely derived from glacially thrust sediment. Possibly some of the underlying stratified sand of the Sand River Formation was eroded and incorporated into the Seibert Lobe, accounting for the sandy texture of the Kehiwin Lake till.

A. Grand Centre Formation: Hilda Lake Member

Source of name: Hilda Lake, located in Tp 64, Rg 3, W4M in the east part of the Sand River map area, NTS 73L.

Type section: Section LA81-1, road cut exposed along the west bank of the Marie Creek in section 30, Tp 63, Rg 2, W4M in the Sand River map area, NTS 73L (Figure 46). At this location the Hilda Lake Member overlies the Marie Creek Formation and is overlain by the Reita Lake Member of the Grand Centre Formation.

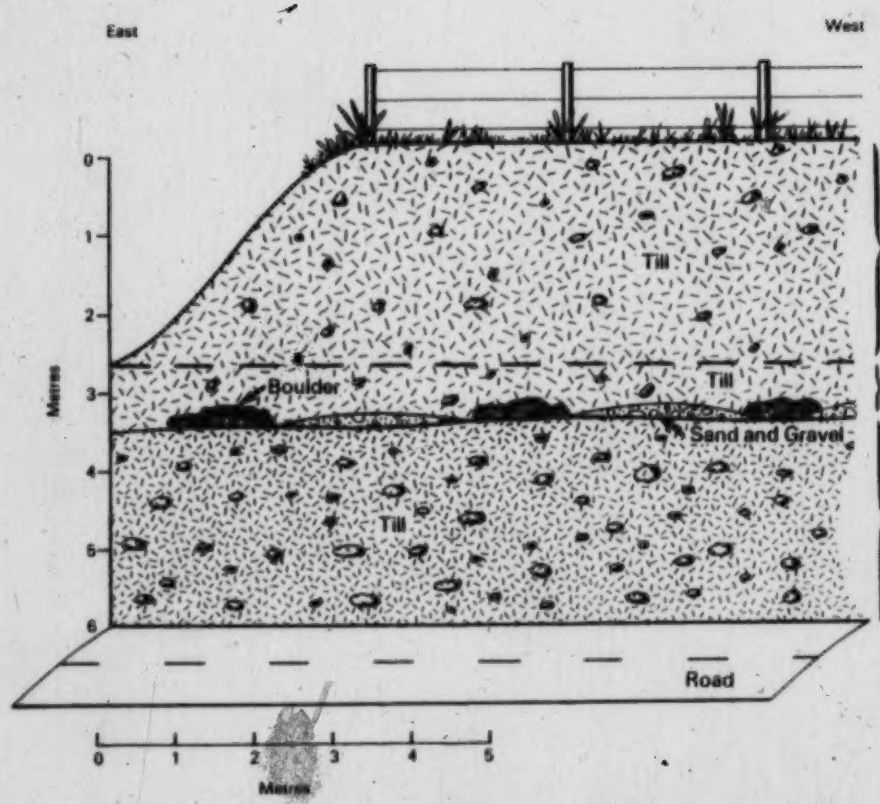
Type area: The type area is defined as the area north of the Beaver River outlined by Tps 62-65, Rgs 1-6 in the east part of the Sand River map area, NTS 73L.

Reference sections: Road cuts exposed on the south side of LSD 16, section 13, Tp 62, Rg 2 W4M, and along Hwy 28 in LSD 13, Sec 10, T62, Rg 2 W4M); Alberta Geological Survey auger testholes T-2 (LSD 4, Sec 15, Tp 65, Rg 2, W4M), T-7 (LSD 4, Sec 1, Tp Rg 6, W4M), and T-32 (LSD 12,Sec 1, Tp 64, Rg 3, W4M).

Description of Unit

The Hilda Lake Member has been mapped from both outcrop and testhole samples. The member consists of clayey diamicton which, in places, contains incorporated blocks of stratigraphically older diamicton, stratified sediment, and shale. The top of the member is poorly oxidized very dark grey-brown (2.5Y 3/2). It becomes unoxidized very dark-grey (5Y 3/1) with depth.

In outcrop the diamicton is massive to slightly fissile though locally larger, slightly iron-stained fractures or joints are present. The unit is moderately stiff but tends to cling to a pick or shovel when excavated. Directly south of Cold Lake significant amounts of glacially transported blocks of shale, sand and silt, and older diamicton form much of the



Grand Centre Formation

Reita Lake Member Dark grey-brown (2.5y 4/2) sandy-clay diamicton; fissile to massive, soft, moist; minor iron staining along joints; few pebbles or granules; increase in clay content with depth.

Depth (m)	Texture %Sand	%Clay	%1-2 mm Sand	Matrix Vol. CO_2	Carbonate %CO_3	Calcite Dolomite
1	37	24	1.7	22	9	.33
2	33	35	1.6	32	13	.27
3	33	52	1.4	29	12	.40

Hilda Lake Member Very dark grey-brown (2.5y 3/2) clayey diamicton; moist, stiff, few pebbles or granules; boulder concentration and discontinuous sand and gravel lenses at base of unit.

Depth (m)	Texture %Sand	%Clay	%1-2 mm Sand	Matrix Vol. CO_2	Carbonate %CO_3	Calcite Dolomite
3.5	20	46	.7	23	10	.12

Marie Creek Formation

Olive brown (2.5y 4/4) sandy diamicton; consolidated, highly fractured with iron and manganese staining; very stony and pebbly.

Depth (m)	Texture %Sand	%Clay	%1-2 mm Sand	Matrix Vol. CO_2	Carbonate %CO_3	Calcite Dolomite
4	55	26	3.1	38	16	.20
5	52	13	4.2	30	13	.22
6	55	10	3.1	31	13	.19

Figure: 46 Type section of the Hilda Lake Member and Reita Lake Member of the Grand Centre Formation. Section LA 81-1 located along the west bank of the Marie Creek (LSD 1 Sec 30 Tp 63 Rg 2 W4M).

member. These were deposited within a glacially streamlined ridge oriented in a southwest direction (Plate 5).

The analytical data show that the average matrix texture of the diamicton consists of about 27% sand, 30% silt, and 43% clay, with very coarse sand making up less than 1% of the matrix (Table 2). The textural variations range from 16% to 33% sand, 25% to 35% silt, and 30% to 55% clay (Table 8). The diamicton characteristically contains few pebbles or granules. The clayey texture results in a relatively higher moisture content of about 13%, which makes the member soft and easy to penetrate with a dry auger.

The composition of the very coarse sand fraction averages about 69% igneous and metamorphic fragments, 23% quartz, 2% limestone, 3% dolostone, 1-2% local rock fragments, and 1% quartzite and quartz sandstone fragments (Table 2). The variations range between 60% to 75% igneous and metamorphic fragments, 17% to 29% quartz, 2% to 5% limestone, 2% to 11% dolostone, 0% to 3% local rock fragments, and 0% to 4% quartzite and quartz sandstone fragments (Table 8).

Calcareous material makes up about 11% of the silt-clay fraction with dolomite more abundant than calcite (calcite / dolomite ratio =.24, Table 2).

The clay mineralogy of a few representative samples consists of about 51% illite, 20% kaolinite, 24% montmorillonite, and 5% chlorite (Appendix B).

Electric log responses indicate that the Hilda Lake Member has a lower resistivity than top of the underlying Sand River and Marie Creek Formations or, the overlying Reita Lake Member.

Distribution, Thickness, and Subcrop Topograophy

The Hilda Lake Member is confined primarily to the central and eastern part of the Sand River map area (Figure 47). The member extends as far north as Tp 66, Rg 5 within the Marguerite Lake Upland, and as far south as the base of the Reita Lake Upland and Moose Lake Highland. The top of the member ranges in elevation from as high as 630 m in the north, to as low as 530 m within the Beaver River Lowland Plain. The member is noticeably absent along a trend which roughly parallels the Beaver River in the east part of the map area (Figure 47).

Table 8. Properties of the Hilda Lake Member of the Grand Centre Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy												Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Cbt. %		Lst. %		Shl. %		Stone & Cly. Sst. %		Local %		CO_3 %		Calcite Dolomite %	
			x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
T3	4-15-63-2-W4M	23	27	1	44	2	8	2	15	1	68	5	28	3	2	1	2	1	37	28	11	7				
T6	15-31-62-3-W4M	1	27		38		9		12		76		17		2		0		30		0		17		28	
T7	6-1-64-6-W4M	11	28	2	38	1	8	1	13	4	72	3	24	4	1	1	1	1	12	15	1	3	11	1	28	1
T8	11-36-63-3-W4M	2	31	8	41	8	15	3	12	1	72	5	20	4	2	4	3	2	11	8	12	11				
T9	13-10-63-2-W4M	2	27	1	46	1	13	2	13	1	70	8	18	3	1	1	3	1	8	4	18	8				
T10	5-18-63-4-W4M	6	25	5	30	3	14	3	14	3	63	3	28	4	8	1	5	1	3	3	38	7				
T11	5-14-62-5-W4M	2	28	1	38	1	7	2	14	13	74	2	21	1	2	1	2	1	10	2	8	6				
T12	4-4-62-4-W4M	7	32	2	35	3	8	2	12	1	71	2	28	3	1	1	1	1	13	8	3	5				
T13B	1-30-60-2-W4M	2	28	9	44	8	11	7	14		64	3	21	3	8	2	8	7	4	5	12	1				
T18	9-18-61-3-W4M	7	33	1	42	1	17	2	14	1	75	3	22	2	1		2	1	10	5	5	5				
T20	1-28-64-5-W4M	3	24		52	3	9	1	14		75		23	1	2		2		19	6	14					
T23	15-22-64-6-W4M	1	27		37		10		18	1	66		28		2		1		10		26					
T25	4-24-62-8-W4M	9	29	2	40	2	10	3	12	1	66	3	28	4	5	4	2	2	11	9	1	2	12	2	28	05
T27	4-8-69-3-W4M	7	28	1	40	1	10	1	15		71	2	23	2	1	1	1	1	15	8	7	3				
T29	8-34-63-2-W4M	2	17	8	58	2	11	5	15	3	68	3	26	2	2	1	3	1	6	8	20	8				
T31	1-2-63-1-W4M	20	25	5	44	5	9	2	13	2	74	4	22	3	1	1	1	1	11	10	3	3				
T32	12-1-66-3-W4M	2	33	4	48	2	9	3	14		69		21	3	3	1	8		0		8	5	11	1	25	07
T34	13-19-63-2-W4M	3	32	1	42	3	15	2	13	1	68	2	38	3	2		4	1	10	5	7	3				
T40	4-30-62-6-W4M	2	28		45	2	8		12		70	3	23	5	1	1	3	1	18		4	6				
T42	13-5-65-3-W4M	4	28	5	38	9	10	8	13	1	63	5	37	6	2	1	9	3	28	3	8	6				
T44	14-29-61-8-W4M	3	31	2	35	4	9	3	12		66	2	28	3	1		2	1	7	8	10	1				
T46	1-9-60-7-W4M	9	29	3	48	3	9	3	12		72	8	21	3	2	1	1	1	10	8	10	8	12	1	21	34
T48	4-28-62-4-W4M	12	24	1	48	2	8	1	14	1	78	3	20	3	2	1	1	1	11	10	4	6	12	1	28	36
T50	16-12-61-5-W4M	2	27	8	38	5	16	3	19	2	74	8	19	3	3	1	8	3	0		3	3				
T52	3-5-60-4-W4M	1	18		54		7		16		9		7		1		1		5		1					
T54	3-28-62-8-W4M	23	30	3	40	4	9	3	14	1	70	8	36	7	2	1	2	1	14	10	2	4	11	2	34	36
T56	16-13-65-2-W4M	5	22	2	48	1	8		13	1	66	8	24	6	4	2	3	1	13	4	29	3	11	3	34	35
T58	1-21-63-3-W4M	9	28	1	33	1	9	1	10		63	2	21	3	3	3	11	6	9	9	7	1				
T75	6-29-62-2-W4M		Variable - Glacially displaced beds of Marie Creek Fm., Bonnyville Fm., and Lea Park Fm.																							
T75R18	9-2-63-9-W4M	6	31	1	48	4	10	1	12		58	3	25	1	3	1	4	1	17	5	17	16				
T75R19	8-13-66-8-W4M	5	25	8	53	8	11	4	9	2	66	2	27	2	1	1	2	1	16	8	2	3				
T75R20	3-6-66-4-W4M	2	27	5	44	5	11	3	16	1	67	2	22	6	2		7	4	10	8	8		10		11	36
Mean of the mean values from all testholes			27	4	43	6	10	2	13	2	68	4	25	3	2	1	3	2	12	6	15	22	11	1	28	38
Total number of samples - n			n = 186		n = 186		n = 186		n = 186		n = 186		n = 186		n = 186		n = 186		n = 186		n = 186		n = 53		n = 53	
Total number of testholes - N			N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 30		N = 8		N = 8	

x̄ - Mean
S.D. - Standard Deviation

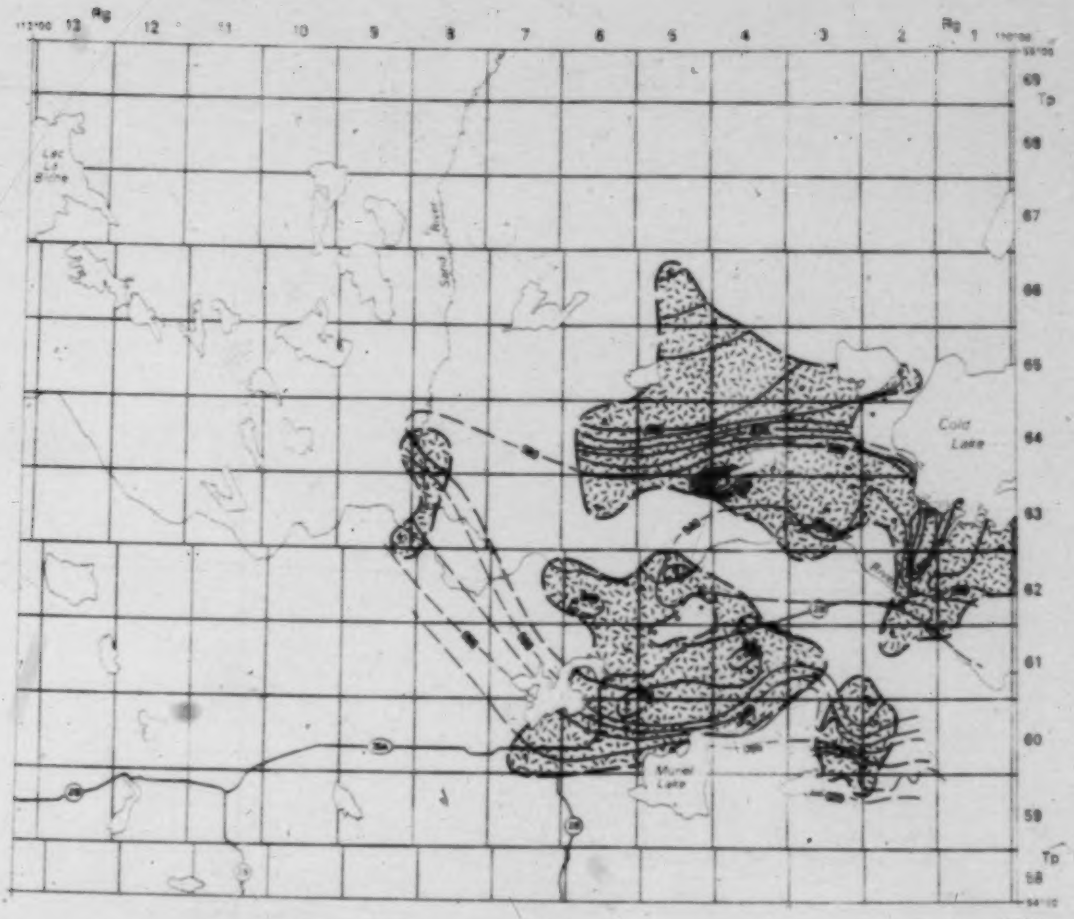

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
Tp
69
68
67
66
65
64
63
62
61
60
59
58
Tp
Lac La Biche
Sand River
Cold Lake
Muriel Lake
W4M

Figure: 47 Elevation of the upper surface of the Hilda Lake Member.

▨ Diamicton (till) and Displaced Sediment

Unit Boundaries:
Approximate.................. — — —
Assumed...................... - - - - -

Contours, Interval 10 metres:
Defined...................... ═══
Approximate.................. ═ ═ ═

Data Location...................... •

Although in most places it is overlain by the Reita Lake Member (Figure 8, x-sec E2-E2'), the Hilda Lake Member does outcrop within a pronounced high relief hummocky, ridge, south Cold Lake in Tps 61-63, Rgs 1-2 and, within glacially streamlined ridges near Angling Lake in Tp 60, Rg 2-3 (Fenton and Andriashek, 1983). Glacially displaced and transported blocks of shale, silt and sand are exposed in both areas (Plate 5).

The thickest deposits of the member are found within the hummocky ridge directly south of Cold Lake. Here, the member is as much as 53 m thick (Figure 48). Thick deposits have also been mapped within a number of discontinuous ridges located along the base of the Medley River and Marguerite Lake Uplands, and west of Cold Lake in Tp 65, Rg 2. Elsewhere, the Hilda Lake Member is generally thin, commonly less than 10 m thick.

Differentiation from other units

The Hilda Lake Member is differentiated from the other members of the Grand Centre Formation on the basis of matrix texture, distribution, stratigraphic position and orientation of glacially-streamlined landforms on its surface.

The Hilda Lake Member is stratigraphically the lowest member of the Grand Centre Formation and, for the most part, it is overlain by the Reita Lake Member (Figure 8, x-sec E1-E1, E2-E2'). These two members can be differentiated by textural and color differences: the Hilda Lake Member is much more clayey and in outcrop generally has a darker grey-brown color compared to the grey-brown to olive-brown color of the Reita Lake Member. Both members have glacially streamlined landforms which are oriented in a southwest direction.

The Hilda Lake Member is differentiated from the Kehiwin Lake Member by the following: the Hilda Lake Member is considerably more clayey, it has a darker grey-brown color, it underlies the Kehiwin Lake Member in the central part of the map area (Figure 8, x-sec E3-E3'), and it contains more igneous and metamorphic fragments in the very coarse sand fraction (Table 2). As well, glacially streamlined features on the surface of the Kehiwin Lake Member have a north-south orientation, in contrast to the northeast-southwest oriented features on the surface of the Hilda Lake Member.

The Hilda Lake and Vilna Members cannot be differentiated on the basis of lithology. Both are clayey and both contain glacially displaced and transported blocks of

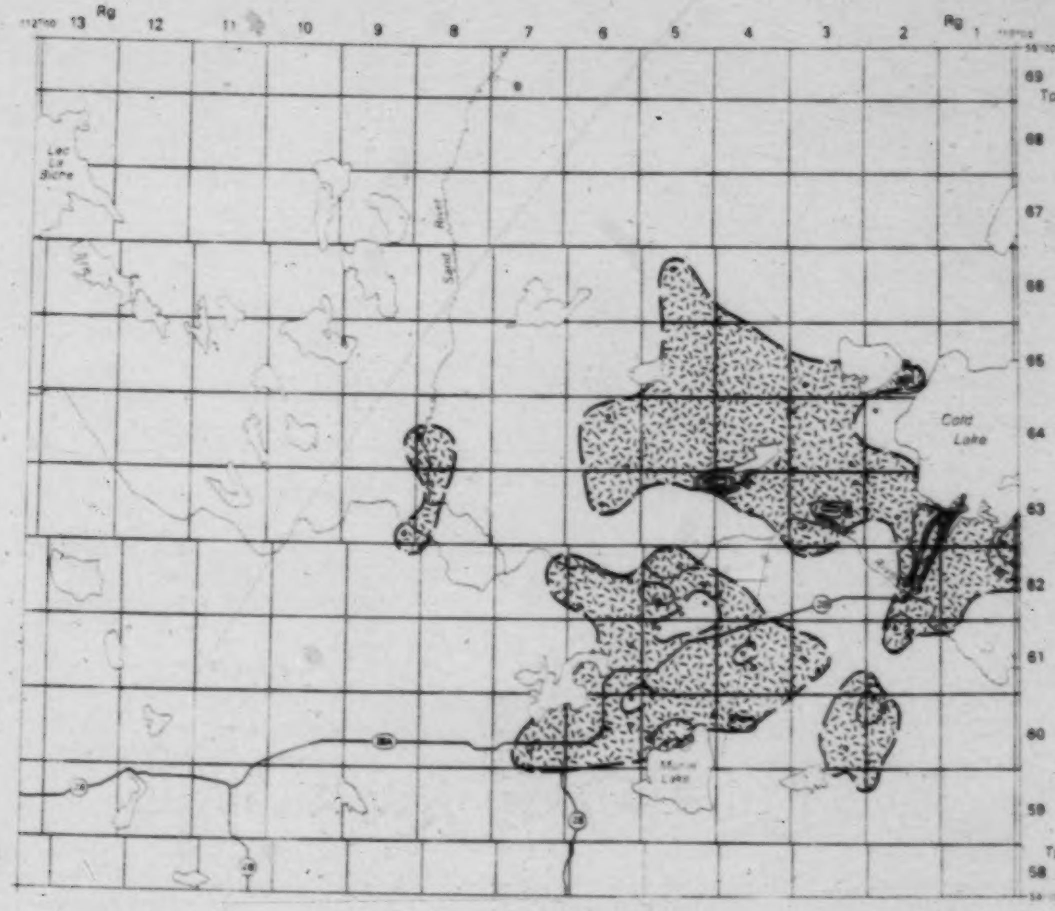

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Lac La Biche
Sand River
Cold Lake
Muriel Lake
W4M

Figure: 48 Thickness of diamicton and glacially displaced sediment in the Hilda Lake Member.
Note the thick, linear deposit that extends southwest of Cold Lake.

▨ Diamicton (till) and Displaced Sediment

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - - -
Isopach, interval 10 metres .... ══ 10 ══
Data Location .... •

older sediment. They can, however, be differentiatied on the basis of geographic distribution, stratigraphic position, and orientation of glacially streamlined features. The Hilda Lake Member lies in the east, and is separated from the Vilna Member, both geographically and stratigraphically, by the Reita Lake and Kehiwin Lake Members. (Figures 9, x-sec N2-N2', and 43). The two members can also be easily differentitaed by the orientation of glacially streamlined landforms. Those on the surface of the Hilda Lake Member are oriented northeast-southwest, whereas those on the surface of the Vilna Member are oriented northwest-southeast (Figure 43).

The Hilda Lake Member is differentiated from the Marie Creek Formation by the following:

1. The Hilda Lake Member is much more clayey and contins fewer pebbles, granules, and less coarse sand than does the Marie Creek Formation (Table 2).
2. The Hilda Lake Member contains more igneous and metamorphic fragments in the very coarse sand fraction, and significantly less carbonate in both the very coarse sand and silt-clay fractions (Table 2).
3. The Hilda Lake Member has a very dark grey-brown color which contrasts markedly with the olive-brown color of the Marie Creek Formation (Plate 4).
4. In outcrop the Hilda Lake Member has a massive to slightly fissile structure whereas the Marie Creek Formation is highly fractured with intensive iron and manganese staining along the joint surfaces.

The Hilda Lake Member is believed to directly overlie the Ethel Lake or Bonnyville Formations in only a few places. The Hilda Lake Member is differentiated from the Bonnyville Formation by the following:

1. The Hilda Lake Member contains significantly more igneous and metamorphic fragments, and less quartz in the very coarse sand fraction (Table 2).
2. The Hilda Lake Member is the most clayey diamicton in the east, whereas the Bonnyville Formation is the most sandy.

Nature of Contacts

Lower Contact

The Hilda Lake Member rests primarily on either the Sand River Formation or the Marie Creek Formation. The contact with the Sand River Formation is generally sharp and disconformable though in a few places a gradational and conformable contact is suggested (Appendix A, testholes T-6 and T-18). In places the contact is difficult to place, firstly because the Hilda Lake Member contains bodies of glacially displaced stratified sediment, similar to that of the Sand River Formation, and secondly because in places the Sand River Formation also contains beds of diamcton with properties similar to those of the Hilda Lake Member.

The contact of the Hilda Lake Member with the top of the Marie Creek Formation is generally sharp and well defined in the field and from the analytical data. In places a boulder concentration marks the contact between the two units (Plate 3). The electric logs show that the Hilda Lake Member has a much lower resistivity than the top of the Marie Creek Formation (Figure 10). The contact between the two units is considered to be disconformable in most places, as indicated by the extensively weathered horizon on the surface of the Marie Creek Formation.

Directly south of Cold Lake the contact may be difficult to determine because the top of the Marie Creek Formation has been eroded and incorporated into the Hilda Lake Member in the form of large, discrete blocks.

Upper Contact

The Hilda Lake Member has a texturally gradational contact with the base of the Reita Lake Member (Appendix A, testholes T-7, T-25, T-32, and 77SR18). This contact is considered to be conformable. Locally within the area defined by Tps 63-64, Rgs 3-5, stratified sediment lies at the contact between the two members (Appendix A, testholes T-6, T-12, and T-27). It is not known if the stratified sediment was deposited contemporaneously with the diamicton of the two members, perhaps as basal meltout sand lenses (Shaw, 1982) or, if its presence indicates a break in the glacial depositional sequence, during which time the area was ice-free.

Origin

The Hilda Lake Member represents glacial sediment which was deposited during the advance of the Primrose Lobe of the Cold Lake Glaciation. Extensive areas of the underlying geology were glacial deformed and displaced by glacial ice-thrusting during the advance of the Primrose Lobe. This eroded the basins of the major lakes in the east part of the map area, including Primrose Lake, Marie Lake, Cold Lake, Wolf Lake, and Muriel Lake. It is believed that the clayey texture of the Hilda Lake till is a result of the incorporation and reworking of shale which was glacially thrust from the southern flank of the buried Helina Valley. Evidence for this consists of large erratic blocks of shale which lie at the surface south of Cold Lake, and, near Angling Lake (Fenton and Andriashek, 1983, and Plate 5, photo from Angling Lake). Similarily, it is thought that shale has been thrust from the areas near Muriel Lake and Moose Lake to produce the clayey texture in the western part of the member.

Some of the underlying till units have also been eroded and incorporated into the Hilda Lake member, though not in large masses such as the displaced shale. This is shown by the calcite to dolomite ratio for the Hilda Lake Member, which is not too disimilar from that of the high dolostone till of the underlying Marie Creek Formation (.24 for the Hilda Lake Member, compared to .17 for the high dolostone facies and .26 for the lower dolostone facies of the Marie Creek Formation, Table 2). This carbonate data suggests that erosion and incorporation of the underlying till has occurred, even though the textural properties of these two till units are significantly different (Table 2).

Most of the variations in the properties of the Hilda Lake Member are related to the varied amount of glacially displaced and transported blocks of older sediment within the member. In some locations however, the clayey texture of the member appears to result from the contemporaneous deposition of the diamicton with stratified silt and clay, rather than incorporation of shale (Appendix A, testholes T-6, T-42, T-44, T-59, 77SR-35).

B. Grand Centre Formation: Reita Lake Member

Source of name: Reita Lake, Alberta, located in Tp 59, Rg 3, W4M in the Sand River map area, NTS 73L.

Type Section: Section LA81-1, road cut exposed along the west bank of the Marie Creek in LSD 1, Sec 30, Tp 63, Rg 2, W4M in the east part of the Sand River map area, NTS 73L (Figure 46). At this location the Reita Lake Member is exposed at the surface and overlies the Hilda Lake Member.

Type Area: The area within the Beaver River Lowland plain, defined by Tps 60-64, Rgs 1-6, W4M, in the east part of the Sand River map area NTS 73L.

Reference Sections: Exposed road cuts along the banks of the Redspring Creek in LSD 11, Sec 28, Tp 60, Rg 1, W4M; Alberta Geological Survey auger testholes T-12 (LSD 4, Sec 4, Tp 62, Rg 4, W4M), T-25 (LSD 4, Sec 24, Tp 62, Rg 6, W4M), T-27 (LSD 4, Sec 6, Tp 64, Rg 3, W4M), T-32 (LSD 12, Sec 1, Tp 64, Rg 3, W4M).

Description of unit

The Reita Lake Member consists of a clayey-sand diamicton which lies at the surface unit over most of the east half of the Sand River map area. Locally the member is composed of interbedded diamicton and stratified sediment or, incorporated masses of older diamicton which has been glacially displaced. The member has been mapped from both outcrops and testhole samples.

The top of the Reita Lake Member is oxidized dark grey-brown (2.5Y 4/2) but becomes unoxidized dark grey (5y 3/1) with depth. In outcrop the upper part of the member is soft and slightly fissile, but becomes more compact and massive with depth (Plate 4). Dry-auger testhole samples show that locally lenses of oxidized sand and silt are interbedded with the diamicton, but the extent and distribution of these are unknown. The member is moist and relatively easy to penetrate with a dry-auger.

The average matrix texture of the diamicton consists of about 38% sand, 26% silt, and 36% clay, with very coarse sand making up about 1.5% to 2% of the matrix (Table 2). The textural variations range between 34% to 51% sand, 22% to 43% silt, and 23% to 43% clay (Table 9). Typically the diamicton contains few pebbles or granules.

The moisture content of the Reita Lake member is varied, reflecting the fact that the member is exposed in most places and is subject to varying degrees of rainfall. The moisture content ranges from about 10% in the sandy samples, to as much as 16% in the clayey samples (Table 9).

The composition of the very coarse sand fraction consists, on average, of about 69% igneous and metamorphic rock fragments, 25% quartz, 2% limestone, 3% dolostone, 1% quartzite and quartz sandstone fragments, and < 1% local rock fragments (Table 2). The variations range between 62% to 75% igneous and metamorphic fragments, 20% to 32% quartz fragments, 0% to 7% limestone, 1% to 4% dolostone, .5% to 3.5% quartzite and quartz sandstone fragments, and .5% to 5% local bedrock fragments (Table 9).

Calcareous material makes up about 11% of the silt-clay fraction with dolomite more abundant than calcite (calcite / dolomite ratio = .28, Table 2).

The clay mineralogy of a few representative samples consists of about 56% illite, 22% kaolinite, 16% montmorillonite, and 6% chlorite (Appendix B).

Glacially streamlined features on the surface of the Reita Lake Member characteristically have a northeast-southwest direction (Figure 43). Orientations of pebbles within the diamicton are varied, showing a weak bimodal distribution with some elements parallel to the surface streamlined features and others perpendicular to that orientation (Figure 49).

Distribution, Thickness and Topography

The Reita Lake Member forms the surface unit over most of the east half of the map area, and is believed to extend south into the Vermilion map area (Figure 50). The western limit of the member is defined essentially by the Sand River in the northern and central part of the map area and, by the Kehiwin Creek and Kehiwin Lake in the south-central part. The top of the member ranges in elevation from as high as 790 m within the Muriel Lake Highlands in the south, to as low as 550 m in the east part of the Beaver River Lowland Plain (Figure 50).

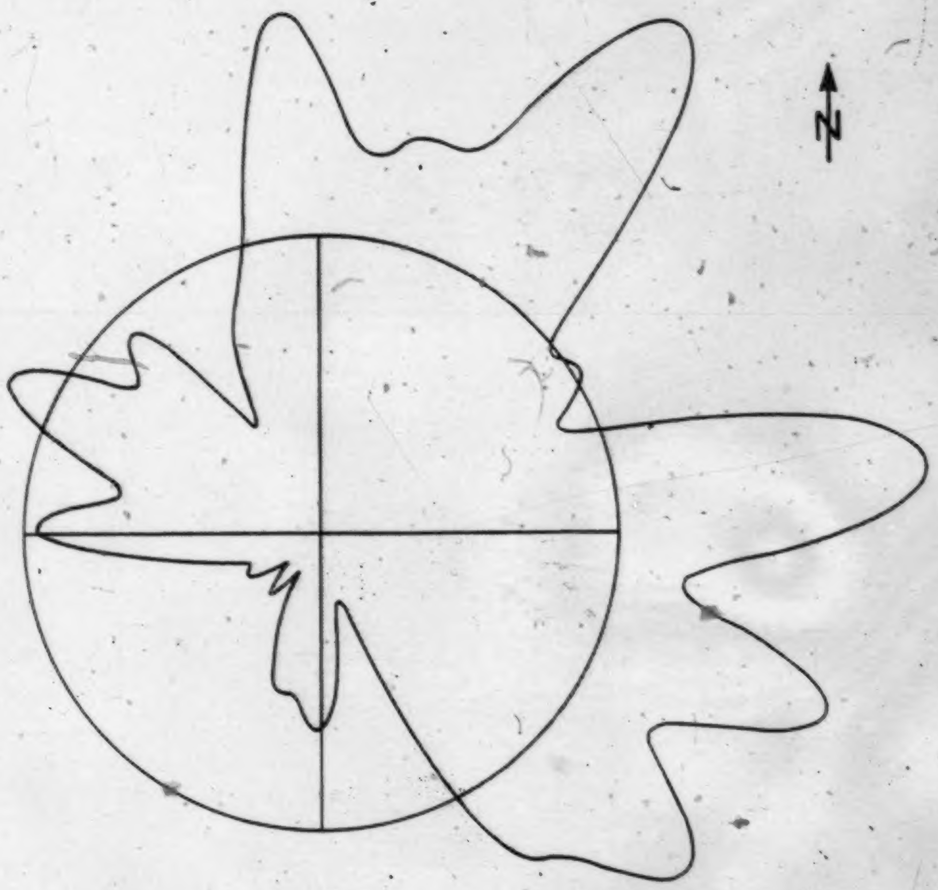
The Reita Lake Member forms a relatively thin drape, generally less than 10 m thick, over most of the Reita Lake and Marguerite Lake Uplands, and within segments of the Beaver River Lowland Plain (Figures 8, x-sec E1-E1' and 51). Thicker deposits of the member are found within two regions: within the east-west oriented uplands which flank the northern and southern margins of the Beaver River Lowland Plain and, in isolated areas

Table 9. Properties of the Reita Lake Member of the Grand Centre Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy												Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dol. %		Chert & Qtz. Sst. %		Local %		CO2 %		Calcite Dolomite %	
			x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
T1	6-36-61-1-W4M	4	44	5	32	1	2.0	6	13	2	68	2	28	2	2	1	4	1	11	4	5	5				
T5	2-16-59-3-W4M	4	38	1	39	2	1.5	4	16	1	70	1	28	4	3	1	3	1	8	7	13	3	12	1	33	1
T6	15-31-62-3-W4M	5	36	2	38	3	1.7	4	15		75	4	20	3	1	1	2	1	12	4	8	2	10	1	30	1
T7	4-1-64-6-W4M	28	35	5	36	6	1.9	4	13	2	68	4	25	4	2	1	2	1	12	8	5	5	12	1	23	34
T10	8-15-63-4-W4M	3	34	3	23	2	1.8	1	8	1	72	2	22	2	3	1	3	1	17	8	11	1				
T11	9-14-62-5-W4M	11	42	4	25	5	1.6	4	12	2	70	3	24	2	2	1	3	1	10	6	6	6				
T12	4-4-62-4-W4M	4	38	2	36	3	1.8	2	16	1	67	2	27	3	2	1	2	0	15	5	6	5				
T13	4-27-60-2-W4M	5	38	2	38	3	1.3	3	14	1	75	4	22	3	2	1	4	1	8	5	1	2				
T14	4-17-65-3-W4M	2	34	2	23	2	1.9	1	12	1	72	2	22	2	3	1	3	1	13	9	11	1				
T15	16-20-65-1-W4M	2	46	3	32	4	1.8	2	12	1	74	3	21	1	1		5		10		5	1				
T16	4-30-61-1-W4M	2	45	1	30	3	2.0	3	9	1	72		21		2		1		8		5					
T17	7-36-61-3-W4M	5	42	4	33	4	1.8	3	12	1	70	3	23	3	2		3	1	14	6	3	4				
T19	16-20-64-2-W4M	3	38	3	37	4	1.5	1	18	2	68	3	28	2	0		3	1	8	8	5					
T22	7-15-66-5-W4M	6	42	2	32	2	1.2	2	13	1	70	4	22	3	2	1	4	1	10	10	6	6				
		12	42	2	32	2	2.9	4	10	3	72	4	20	1	2	1	4	1	10	10	6	5				
T25	15-22-64-6-W4M	3	41	1	32	1	1.7	1	11	1	63	2	30		2		3	2	6	6	6	3				
T26	4-24-62-6-W4M	7	40	4	36	2	1.8	2	10	2	67	3	28	4	3	1	1	1	21	20	2	3	11	2	27	1
T27	4-6-64-3-W4M	3	35	4	34	1	1.6	1	13	1	75	1	26	6	2	1	2	1	23	7	6	4				
T30	13-4-62-3-W4M	2	27	5	40	6	1.7	0	14	2	72	5	24		2	1	2	1	18	11	16		12		30	
T31	1-2-63-1-W4M	15	38	1	36	2	2.0	3	13	1	76	4	20	3	1	1	2	2	7	4	6	5				
T32	12-1-64-3-W4M	7	38	2	38	3	1.8	1	14	1	68	2	27	1	2	1	4	1	17	8	6	5	11	1	27	38
T33	5-32-65-1-W4M	1	41		40		2.8		13		70		26		1		2		4		5					
T35	12-27-63-7-W4M	12	34	2	38	1	1.5	2	12	1	66	4	27	4	2	1	3	1	8	7	4	4				
T36	13-4-63-6-W4M	10	35	2	37	4	1.5	2	12	2	71	5	25	3	1	1	2	1	13	10	13	8				
T38	4-35-64-7-W4M	3	44	2	32	1	1.6		11	1	62	3	27	2	3		2		24	3	5	2				
T41	3-29-58-3-W4M	7	38	3	38	4	1.5	1	14	1	64	4	28	3	2	1	3	1	2	2	11	8				
T42	13-3-65-3-W4M		Visual site of the Reita Lake Member and overthrust Marie Creek Formation																							
T44	14-24-61-6-W4M	6	40	3	36	3	1.8	2	10		71	3	24	3	2	1	2	1	11	14	6	5				
T45	1-9-65-7-W4M	8	38	3	36	3	1.4	3	12	1	66	4	24	3	2	1	3	1	8	8	11	8	10	1	28	34
T46	16-23-65-6-W4M	16	37	3	35	4	1.6	2	11	1	68	3	27	4	3	3	2	2	15	8	8	11				
T47	12-36-65-6-W4M	6	38	3	37	2	1.4	2	12	1	66	6	28	8	1	1	3	2	17	8	7	10				
T48	4-29-65-4-W4M	9	38	1	38	2	1.8	2	12	1	66	2	28	2	1	1	2	2	11	7	4	8	13	2	27	1
T49	16-12-61-5-W4M	4	38	1	38	1	1.8	3	14	1	71	2	22	4	2	1	4	1	5	7	6	8	13	2	27	1
T50	16-10-66-6-W4M	2	40	1	32	2	1.5	2	10	1	66	6	25	1	0		2	1	3	3	18	4				
T52	3-5-65-4-W4M	3	38	1	38	3	1.6	3	12		70	3	27	2	2	1	1	1	18	4	18	11				
T53	4-21-61-4-W4M	22	37	3	34	2	1.6	3	11	1	76	4	24	4	1	1	2	1	8	5	4	4				
T56	14-6-63-4-W4M	8	37	3	38	2	1.4	3	10	1	70	3	25	2	1	1	3	1	7	8	6	5				
T57	16-8-60-6-W4M		Variable - Glacially stacked sequence of older till																							
T58	16-13-62-2-W4M		Variable - Glacially displaced beds of Bonnyville Formation till																							
T66	1-21-63-3-W4M	5	34	3	43	5	1.6	3	12	1	68	4	22	3	1	1	6	1	16	10	7	6	9	6	30	1
T69	12-29-63-6-W4M	18	37	2	35	2	1.8	2	10	1	70	4	24	3	3	1	3	1	8	7	6	6				
T71	9-25-59-6-W4M	3	38	2	38	3	1.6	2	16	2	72	3	28		4	1	2	1	7	3	9	5				
T72	6-1-65-1-W4M	6	44	1	32	1	2.2	3	11		71	2	25	1	1		1	1	15	6	8	3				
T73	3-6-65-7-W4M	3	42	6	33	8	1.6	3	9	1	66	8	25	2	7		6		8	5	16	3				
77SR17	15-8-61-6-W4M	9	36	3	38	3	1.7	3	9		66	5	24	3	2	1	4	2	18	5	4	1				
77SR18	9-3-60-6-W4M	5	36	4	41	3	1.3	2	11	1	66	2	27	3	1	1	3	1	1	5	5	5				
77SR19	9-13-64-6-W4M	2	38		40	4	2.0	6	8		52		43		1	1	0		15	13	8	6				
		2	30	5	46		1.6	1	13	3	63	5	32	6	1		3	1	6	6	5	6				
		8	38	3	44	2	1.7	2	9	1	70	2	27	2	1		1		7	6	8	3				
77SR23	4-27-60-7-W4M	30	Thrust Marie Creek Formation																							
77SR24	16-20-65-6-W4M	16	45	4	32	4	2.8	1.1	11	1	71	3	22	3	2	1	3	1	6	6	15	10				
77SR26	2-6-65-4-W4M	10	40	2	38	2	1.7	2	12	1	68	2	27	3	1	1	1	1	16	6	3	2	10	1	20	34
77SR28	5-24-65-4-W4M	7	42	1	35	1	1.8	4	13	1	64	4	24	2	3	2	4	2	36	6	11	1	24	1		
Mean of the mean values from all testholes			38	4	36	6	1.7	.3	12	2	68	4	25	4	2	2	3	1	12	6	8	7	11	1	28	34
Total number of samples n			n = 280		n = 280		n = 280		n = 280		n = 280		n = 280		n = 280		n = 280		n = 280		n = 280		n = 77		n = 77	
Total number of testholes N			N = 51		N = 51		N = 17		N = 51		N = 51		N = 51		N = 51		N = 51		N = 48		N = 51		N = 11		N = 11	

x̄ - Mean
S.D. - Standard Deviation

Smoothed Rose Diagram
Section LA 81-2 LSD 3 Sec 16 Tp 63 Rg 2 W4M



K (smoothing factor) = 90
N (number of measurements) = 89

Figure: 49 Pebble orientations in the diamicton of the Reita Lake Member.

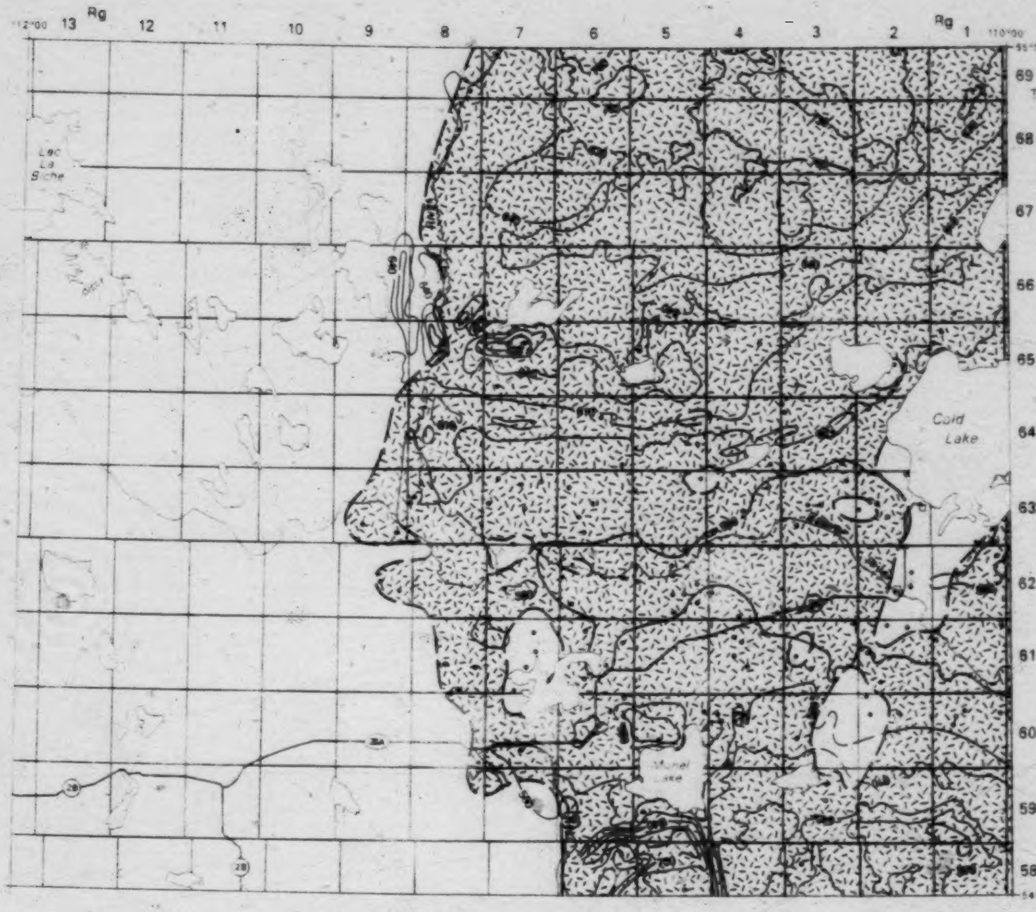

112°00
13
Rg
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
55°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
W4M
Lac La Biche
Cold Lake
Muriel Lake
28
28
28A

Figure: 50 Elevation of the upper surface of the Reita Lake Member.

▨ Diamicton (till)

Unit Boundaries:
Approximate........................ — — —
Assumed.............................. - - - - - - -
Contours, Interval 30 metres:
Defined............................. 550
Approximate........................ 550
Data Location............................. •

along the western margin of the Beaver River Lowland Plain (Figure 51). It is believed that sequences of glacially displaced, older sediment, form thick deposits of the Reita Lake Member within the Muriel Lake Highland, but data are lacking from that area.

The thickest deposits of the Reita Lake Member are found within the isolated highlands in the east part of the map area. Within these highlands the member consists primarily of stratigraphically older till, mainly the Marie Creek till, which has been glacially displaced by ice-thrusting. In the Wolf Lake and Primrose Lake Highlands, more than 60 m of the Marie Creek till have been incorporated into the Reita Lake Member, and only a thin to discontinuous drape of the Reita Lake diamicton lies on top (Figure 51, and Appendix A, testholes T-1 and 77SR-33). Similarily, in the Marie Lake Highland thick slabs of the Marie Creek till have been glacially thrust from the bottom of Marie Lake and deposited as a discrete slab on top of the diamicton of the Reita Lake Member (Appendix A, testhole T-42).

Differentiation from other units

The differentiation between the Reita Lake Member and Hilda Lake Member is discussed in the previous section. The Reita Lake Member is differentiated from the Kehiwin Lake Member by the following:

1. The Reita Lake Member has a darker grey-brown color compared to the olive-brown color of the Kehiwin Lake Member.
2. The Reita Lake Member is generally more clayey and less sand than the Kehiwin Lake Member (Table 2).
3. The Reita Lake Member is stratigraphically lower and underlies the Kehiwin Lake Member along the contact (Figure 9, x-sec N2-N2').
4. The Reita Lake Member contains marginally more igneous and metamorphic fragments, and less quartz in the very coarse sand fraction (Table 2).
5. Glacially streamlined features on the surface of the Reita Lake Member are oriented in a northeast-southwest direction, whereas those of the Kehiwin Lake Member are oriented in a north-south direction (Figure 43).

The Reita Lake Member is geographically and stratigraphically separated from the Vilna by the Kehiwin Lake Member (Figure 9, x-sec N2-N2'). As well, the orientation of the

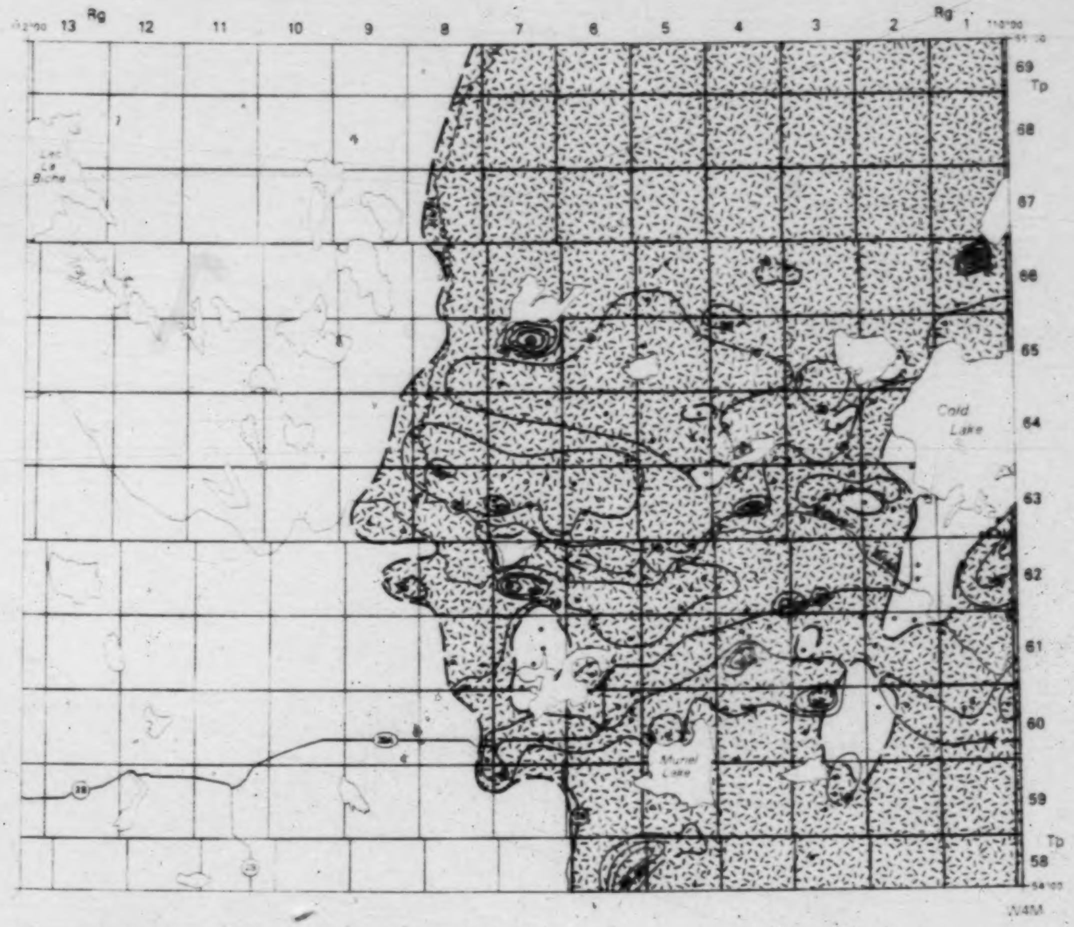

112°00
Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
110°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Lac La Biche
Cold Lake
Muriel Lake
W4M

Figure: 51 Thickness of diamicton in the Reita Lake Member.

▨ Diamicton (till)

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -
Isopach, Interval 10 metres .... —50—
Data Location .... •

glacially streamlined features on the surface of the Reita Lake Member are orthogonal to the orientation of those features on the surface of the Vilna Member (Figure 43).

The Reita Lake Member is differentiated from the Marie Creek Formation by the following:

1. The Reita Lake Member has a dark grey-brown oxidized color which contrasts to the olive-brown oxidized color of the Marie Creek Formation (Plate 4).
2. The structure of the Reita Lake Member is massive to slightly fisssile whereas the Marie Creek Formation is highly fractured with abundant iron and manganese staining along the fracture surfaces.
3. The Reita Lake Member is less sandy than the Marie Creek Formation, particularly in the amount of very coarse sand (Table 2). In the northern part of the map area where both units are as sandy, this differentiates the two units.
4. The Reita Lake member contains much less carbonate in both the very coarse sand and silt-clay fractions (Table 2).

In most places the Reita Lake Member is separated from the Bonnyville Formation by other units, and thus the two commonly can be differentiated by stratigraphic position. In those places where the two are in contact they are differentiated by the more clayey texture and abundance of igneous and metamorphic rocks in the very coarse sand fraction of the Reita Lake Member (Table 2).

Nature of Contacts

Lower Contact

The contact of the Reita Lake Member with the top of the Hilda Lake Member and Sand River Formation, is discussed in the previous sections.

The contact of the Reita Lake Member with the top of the Marie Creek Formation is generally sharp and well defined from the field observations and the analytical data. In places a boulder concentration lies along this contact. The contact is less well defined in those areas where glacial ice-thrusting has displaced some or all of the underlying Marie Creek Formation and incorporated this material into the Reita Lake Member.

Gradational contacts are indicated by the very coarse sand composition in some places. Testholes T-5 and T-38 (Appendix A), show that the base of the Reita Lake Member contains significanlty more carbonate rock fragments than normal, indicating erosion and incorporation of the underlying till of the Marie Creek Formation.

On the basis of the extensive oxidized profile on the surface of the Marie Creek Formation, the contact with the Reita Lake Member is considered to be disconformable.

Upper Contact

The Reita Lake Member forms the surface unit over most of the east part of the Sand River map area, except where it is overlain by post-glacial stratifed deposits (Fenton and Andriashek, 1983). The Reita Lake member is buried by the Kehiwin Lake Member along its western margin. The contact is commonly gradational and varied; in places the Kehiwin Lake Member overlies the Reita Lake Member, in other places the two interfinger, forming an apparent lateral contact (Figure 9, x-secs N1-N1' and N2-N2' testholes 77SR-18 and 77SR-19). In places stratified sediment lies along the contact but the extent and distribution of this sediment is believed to be limited (Appendix A, testhole 77SR-19). The contact is considered to be conformable (Figure 53).

The contact is also clearly defined on the surface by the intersection of the southwest oriented streamlined landforms of the Reita Lake Member, with the north-south oriented streamlined landforms of the Kehiwin Lake Member (Figure 43).

Origin

Diamicton of the Reita Lake Member represents till which was deposited by the Primrose Lobe during the advance of the Cold Lake Glacier (Figure 43). As discussed previously, glacial ice-thrusting was associated with the advance of the Primrose Lobe, and locally much of the underlying geology was either deformed, or displaced by the overriding ice. In particular, till of the Marie Creek Formation was displaced from the major lake basins in the east, and transported southward to form very high relief thrust landforms (Fenton and Andriashek, 1983).

It is uncertain if the Reita Lake Member was deposited by the same advance of the Primrose Lobe which deposited the Hilda Lake Member, or, from a later one. There is evidence which suggests that both the Hilda Lake and the Reita Lake Members were deposited during the same event. For example, the gradational contact between these members, as well as the similarity in the orientation of glacially streamlined landforms on the surface of these members suggests that they are textural facies of one till sheet, deposited during a single glacial event.

The stratigraphic and geomorphic evidence, on the other hand, supports a model in which the Hilda Lake and Reita Lake Members were deposited by separate advances of the Primrose Lobe. Firstly, the stratigraphic record shows that in a number of places in the east central part of the map area, stratified sediment lies between till of the Hilda Lake and Reita Lake Members (Appendix A, testholes T-6, T-12). If this sediment is in situ, and does not represent glacially displaced masses of older sediment, its presence implies either one of the follwoing possiblities: the sediment was deposited synchronously with the diamicton, by basal melt-out (Shaw 1982); the sediment represents stratified beds within resedimented diamciton, deposited by supraglacial ablation (Lawson 1979); it represents glaciofluvial or glaciolacustrine sediment deposited after, or during, the retreat of the glacier which deposited the Hilda Lake till. Assuming the latter hypothesis, this sediment was subsequently buried by a readvance of the Primrose Lobe, which deposited the Reita Lake till. There is geomorphic evidence to support this hypothesis. Directly south of Cold Lake, some of the glacially thrust landforms on the surface of the Hilda Lake Member are smoothed and subdued, suggesting that they were overriden and remolded by a later glacial advance. In fact, a large thrust moraine which appears to have extended across the entire south end of Cold Lake, (but which is present only along the southeastern part of the lake) was breached, and a considerable portion of that moraine was remobilized and redeposited along the eastern flank of the readvancing lobe (Fenton and Andriashek, 1983). Possibly, the Reita Lake Member was deposited overtop of the Hilda Lake Member by this lobe.

At some time during its history the Primrose Lobe formed an ice-margin in the central part of the map area. This margin extended essentially north-south, roughly parallel to the present day course of the Sand River in the north, and the Kehiwin Creek and

Kehiwin Lake in the south. This margin is shown in Figure 43 and, by the meltwater channel, ice-contact outwash system which trends due south along the Sand River and Kehiwin channel in the recently published surficial geology map of Sand River (Fenton and Andriashek, 1983).

Table 9 and Figure 52 show that there are significant textural differences in the till of the Reita Lake Member. For example, the till is much more sandy and less clayey within the uplands north of the Beaver River Lowland Plains and within the Beaver River Lowland Plain in Tps 60-61, Rg 1. In these two areas the texture of the Reita Lake Member is not too dissimilar from that of the underlying Marie Creek Formation except that the latter contains a greater amount of coarse sand and granules. A possible explanation for the sandier texture of the Reita Lake Member in the north part is that the till was deposited in a supraglacial environment in which fluvial sorting removed some of the fines. The hummocky, collapse topography of the top of the Reita Lake Member in the north supports this interpretation (Fenton and Andriashek, 1983). The sandier texture (including a greater amount of coarse sand as well) of the Reita Lake till in the east part of the Beaver River Lowland Plain on the other hand, is believed to be the result of erosion and incorporation of the underlying sandy Marie Creek till. (Appendix A, testholes T-16, T-17, T-22 and T-72).

The other significant differences in lithology and composition of the Reita Lake Member relate to the abundance of glacial ice-thrust sediment, mainly till of the Marie Creek Formation, within the highlands in the east half of the map area.

C. Grand Centre Formation: Kehiwin Lake Member

Source of name: Kehiwin Lake, Alberta, located in Tp 58 -59, Rg 7, W4M, within the south-central part of the Sand River map area, NTS 73 L.

Type Section: Alberta Geological Survey auger testhole 77SR-17 located in LSD 15, Sec 9, Tp 61, Rg 8,. W4M in the Sand River map area, NTS 73L (Figure 53). At this location the Kehiwin Lake Member overlies the Reita Lake Member of the Grand Centre Formation.

Type Area: The area around and south of the town of Glendon, in the south-central part of

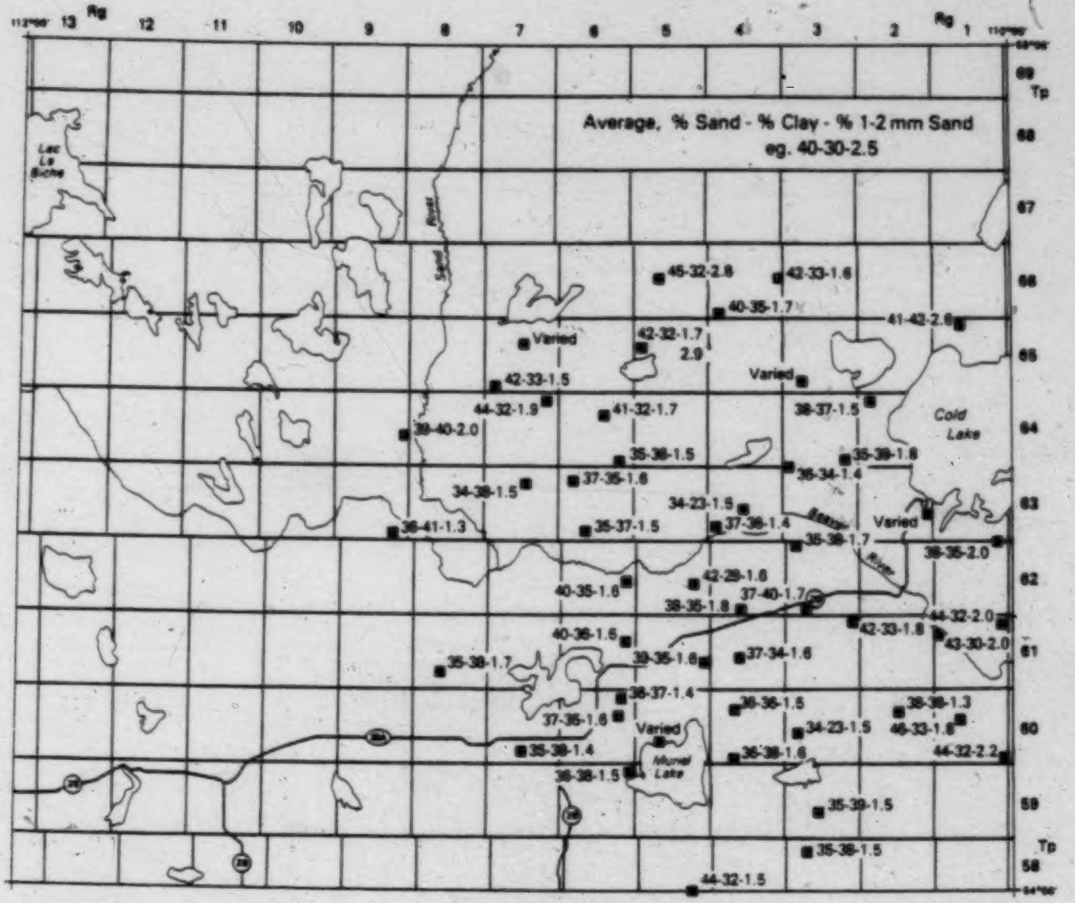
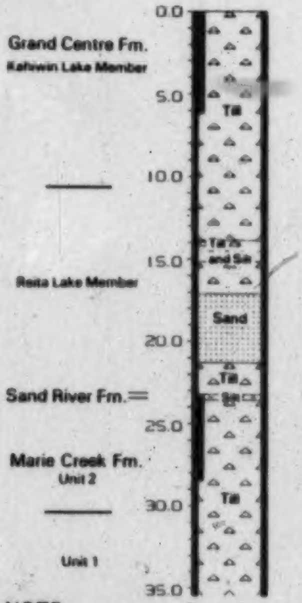

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
Average, % Sand - % Clay - % 1-2 mm Sand
eg. 40-30-2.5
Tp
69
68
67
66
65
64
63
62
61
60
59
Tp
58
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
45-32-2.8
42-33-1.6
40-35-1.7
41-42-2.6
Varied
42-32-1.7
2.9
Varied
42-33-1.5
44-32-1.9
41-32-1.7
38-37-1.5
39-40-2.0
35-38-1.5
35-39-1.8
36-34-1.4
34-38-1.5
37-35-1.6
34-23-1.5
36-41-1.3
35-37-1.5
37-38-1.4
Varied
36-38-1.7
38-35-2.0
40-35-1.6
42-29-1.6
37-40-1.7
38-35-1.8
44-32-2.0
42-33-1.8
40-36-1.5
43-30-2.0
35-38-1.7
39-35-1.6
37-34-1.6
36-37-1.4
38-36-1.5
38-38-1.3
37-35-1.6
Varied
34-23-1.5
46-33-1.6
35-38-1.4
36-38-1.6
44-32-2.2
36-38-1.5
35-39-1.5
35-38-1.5
44-32-1.5

Figure: 52 Regional variations in the textural properties of the Reita Lake Member. Note the sandier texture of the member in the north and along the eastern boundary of the map area.

77 SR 17

Alberta Geological Survey Testhole 77 SR 17
Location NE of LSD 15 Sec 9 Twp 61 Rng 8 W of 4 Mer , NTS 73L
Elevation 1900 Ft 579 M Source 1 50,000 NTS 73L/6
Date drilled 197708 08 Logged by ANDRIASHEK



NOTE:
Heavy Bar Denotes Oxidized Profile

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								7.6				69.8	22.2	6.6	0.0	0.5	0.8	0.0	364
2.00	44.0	26.2	29.8	46.5	29.2	24.3	1.05	12.7				53.7	27.2	5.7	6.3	6.1	0.8	0.0	521
3.00	45.5	26.0	28.6	48.1	27.5	24.4	1.08	11.5				55.0	24.8	5.0	7.0	6.8	1.4	0.0	560
4.00	46.2	25.5	28.2	49.0	26.8	24.2	1.30	11.0				57.0	25.0	4.5	5.9	5.7	1.7	0.0	420
5.00	45.7	25.5	28.8	48.5	26.7	24.8	1.18	10.1				57.7	26.3	5.1	5.3	4.1	1.4	0.0	414
6.00	40.0	26.5	33.5	42.7	28.6	28.7	1.07	9.7				55.5	26.5	3.4	4.0	3.4	1.5	5.5	476
7.00	37.3	26.5	36.2	38.9	29.1	31.0	1.27	9.6				64.8	25.2	2.3	3.6	1.0	2.5	0.5	392
8.00	37.9	26.2	35.9	40.4	29.0	30.6	2.25	10.4				55.2	24.0	2.4	2.1	4.5	0.9	10.8	333
9.00	41.6	26.9	31.5	44.4	29.2	26.4	1.80	8.4				46.2	20.5	1.6	2.4	5.3	1.6	0.0	448
10.00	40.9	26.7	32.4	43.6	28.6	27.8	1.65	8.7				56.0	22.0	1.6	0.4	2.5	0.9	16.5	441
11.00								11.3				76.1	16.8	2.2	0.9	2.2	1.3	0.4	226
12.00	37.4	22.5	40.1	40.0	26.8	33.3	1.47	11.5				66.8	24.0	1.1	2.5	3.0	1.1	1.3	525
13.00								11.6				70.4	21.5	1.6	1.9	2.8	1.4	0.3	362
14.00	32.5	33.9	33.6	35.3	37.8	26.9	1.75	8.4				61.8	19.2	0.7	1.7	16.0	0.5	0.0	411
15.00								8.2				67.1	24.5	2.0	1.6	4.1	0.4	0.0	441
16.00	31.5	28.9	39.5	34.0	33.9	32.2	1.39	8.6				65.2	24.2	2.0	2.8	5.4	0.3	0.0	351
22.00	38.8	24.7	36.5	42.0	27.0	31.0	1.65	9.0				62.6	25.7	1.3	4.2	5.8	0.3	0.0	377
23.00	35.2	27.4	37.4	38.0	29.8	32.2	0.87	8.5				72.8	25.3	0.4	0.4	0.8	0.2	0.0	470
24.00								18.5											
25.00								10.3				57.3	14.8	0.3	4.4	20.9	2.3	0.0	344
26.00	33.2	24.1	42.8	35.6	29.1	35.3	2.32	9.5				64.8	18.5	0.6	1.8	12.4	1.8	0.0	498
27.00	36.2	26.8	37.0	39.3	29.9	30.8	2.56	8.9				64.8	18.0	0.8	3.5	11.1	0.8	1.0	515
28.00	37.1	30.1	32.8	40.3	32.2	27.5	2.54	8.3				58.9	18.9	0.6	4.1	16.7	0.7	0.0	538
29.00	38.6	30.3	31.1	41.5	32.9	25.6	2.40	7.7				60.0	15.5	0.4	2.7	18.6	1.3	1.3	515
30.00	39.5	31.8	28.7	42.4	34.5	23.0	2.38	7.7				47.0	23.8	0.3	2.4	12.0	1.8	12.6	332
31.00	35.7	22.0	42.3	38.1	27.3	34.6	1.75	8.6				60.3	28.5	0.2	3.1	4.2	1.1	2.6	453
32.00	34.9	20.8	44.3	37.3	26.6	36.1	1.76	8.9				61.2	25.9	0.2	2.8	7.7	1.8	0.2	428

Figure:53 Type section of the Kehiwin Lake Member of the Grand Centre Formation. Alberta Geological Survey testhole 77SR 17 (LSD 15 Sec 9 Tp 61 Rg 8 W4M).

the Sand River map area, NTS 73L.

Reference Sections: Alberta Geological Survey auger testholes 77SR-1 (LSD 1, Sec 28, Tp 58, Rg 8, W4M), 77SR-9 (LSD Sec 7, Tp 60, Rg 8, W4M), 77SR-18 (LSD 9, Sec 2, Tp 63, Rg 9, W4M).

Description of Unit

The Kehiwin Lake Member consists primarily of sandy diamicton which is locally overlain by stratified sand and gravel in the southwest corner of the map area. The member has been mapped throughout much of the west half of the map area, primarily from dry-auger testhole samples since the top of the member outcrops only in the central area. The top of the Kehiwin Lake Member is oxidized olive-brown (2.5Y 4/4), but becomes unoxidized dark olive-grey (5Y 3/2) to very dark-grey (5y 3/1) with depth.

In outcrop the diamicton is sandy, but contains few pebbles or granules. Near the type section the diamicton commonly contains numerous lenses and layers of sand. Typically the member is well jointed and has a blocky structure, with iron and manganese staining along the fracture surfaces.

The average matrix of the diamicton consists of about 43% sand, 32% silt, and 25% clay, with very coarse sand making up about 2% of the matrix (Table 2). The textural variations range from between 40 % to 55% sand, 30% to 40% silt, and 15% to 35% clay (Table 10). The sandy texture is reflected in a relatively low moisture content of about 10%.

The composition of the very coarse sand fraction averages about 62% igneous and metamorphic fragments, 29% quartz, 1% quartzite and quartz sandstone fragments, 3% limestone, 3% dolostone, and 1% local bedrock fragments (Table 2). The variations range between 57% to 69% igneous and metamorphic fragments, 23% to 35% quartz, .5% to 4.5% quartzite and quartz sandstone fragments, 2% to 5% limestone, 2% to 5% dolostone, and 1% to 2% locally derived bedrock fragments (Table 10).

Calcareous material makes up about 8% of the silt-clay fraction with dolomite more abundant than calcite (calcite/dolomite ratio = .32, Table 2).

Table 10. Properties of the Kehiwin Lake Member of the Grand Centre Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location	n	Properties of Matrix Texture								1-2 mm Coarse Sand Mineralogy												Matrix Carbonate			
	LSD-Sec-Tp-Rg-M		Sand %		Clay %		1-2 mm Sand %		Moisture %		Igneous Metam. %		Qtz. %		Lst. %		Dst. %		Chert & Qtz. Sst. %		Local %		CO₂ %		Calcite Dolomite %	
			X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.
77SR1	1-28-58-8-W4M	8	41	3	18	1	2.1	6	11	1	58	2	28	2	3	1	3	1	7	4	11	5				
77SR2	14-17-58-7-W4M	17	37	2	25	5	1.7	2	11	1	60	3	32	3	3	1	2	1	1.2	8	2.0	7	8	1	35	1
77SR3	16-10-58-10-W4M	32	41	2	20	1	2.3	2	11	1	61	3	31	3	3	1	3	1	4	4	1.2	5	10	2	29	1
77SR4	13-14-58-11-W4M	28	45	1	19	2	2.5	2	11	1	58	3	27	3	3	1	3	1	6	8	8	5				
77SR6	3-26-58-13-W4M	18	47	2	28	2	2.1	2	11	1	61	4	31	3	3	1	3	1	4	5	2.0	1.1				
77SR7	16-29-59-11-W4M	28	48	1	23	2	2.2	2	11	1	57	3	35	3	3	1	3	1	7	3	1.4	1				
77SR9	16-7-60-8-W4M	7	43	4	18	3	1.1	1	8	1	56	4	24	3	4	2	4	1	2.2	1.2	1.9	8				
77SR10	1-33-58-8-W4M	42	43	4	20	4	2.3	6	8	1	65	5	28	4	3	1	3	1	6	5	1.2	7				
77SR11	1-8-59-10-W4M	28	44	2	25	2	2.5	2	9	1	58	3	34	3	3	1	3	1	4	3	1.6	9				
77SR15	9-15-61-13-W4M	8	43	2	28	1	1.9	2	10	1	63	3	30	4	3	1	3	1	7	3	1.2	.7				
77SR16	9-18-61-9-W4M	34	Interfingering tills of the Vilna and Kehiwin Lake Members																							
77SR17	15-9-61-8-W4M	9	42	3	32	3	1.2	1	11	1	58	1	25	2	5	2	5	1	4.4	1.6	1.3	5				
77SR18	9-2-63-8-W4M	3	40	2	31		1.7	3	10	1	63	2	30	4	2	1	3	1	4	4	1.2	7				
77SR19	8-13-64-9-W4M	13	45	2	34	2	2.4	2	8	1	60	3	28	3	2	1	3	1	4	3	7	8				
77SR23	11-29-65-10-W4M	7	48	1	25	3	2.3	3	10		60	3	23	2	4	1	3	1	6	1	1.3	.4				
	Thrust Marie Creek Till	4	21	6	33	4	9	2	13	1	57	2	28	2	5	1	6	1	4		1.2					
77SR25	6-29-65-9-W4M	30	Highly variable properties																							
77SR26	2-8-66-10-W4M	24	42	2	25	2	2.3	2	12	1	60	3	25	3	2	1	3	1	6	5	9	7				
Mean of the mean values from all testholes			43	3	25	6	2.0	5	10	1	62	4	29	4	3	1	3	1	9	10	1.3	5	8	3	32	34
Total number of samples -n			n = 325		n = 325		n = 325		n = 325		n = 325		n = 325		n = 325		n = 325		n = 325		n = 325		n = 48		n = 48	
Total number of testholes -N			N = 17		N = 17		N = 17		N = 17		N = 17		N = 17		N = 17		N = 17		N = 16		N = 17		N = 2		N = 2	

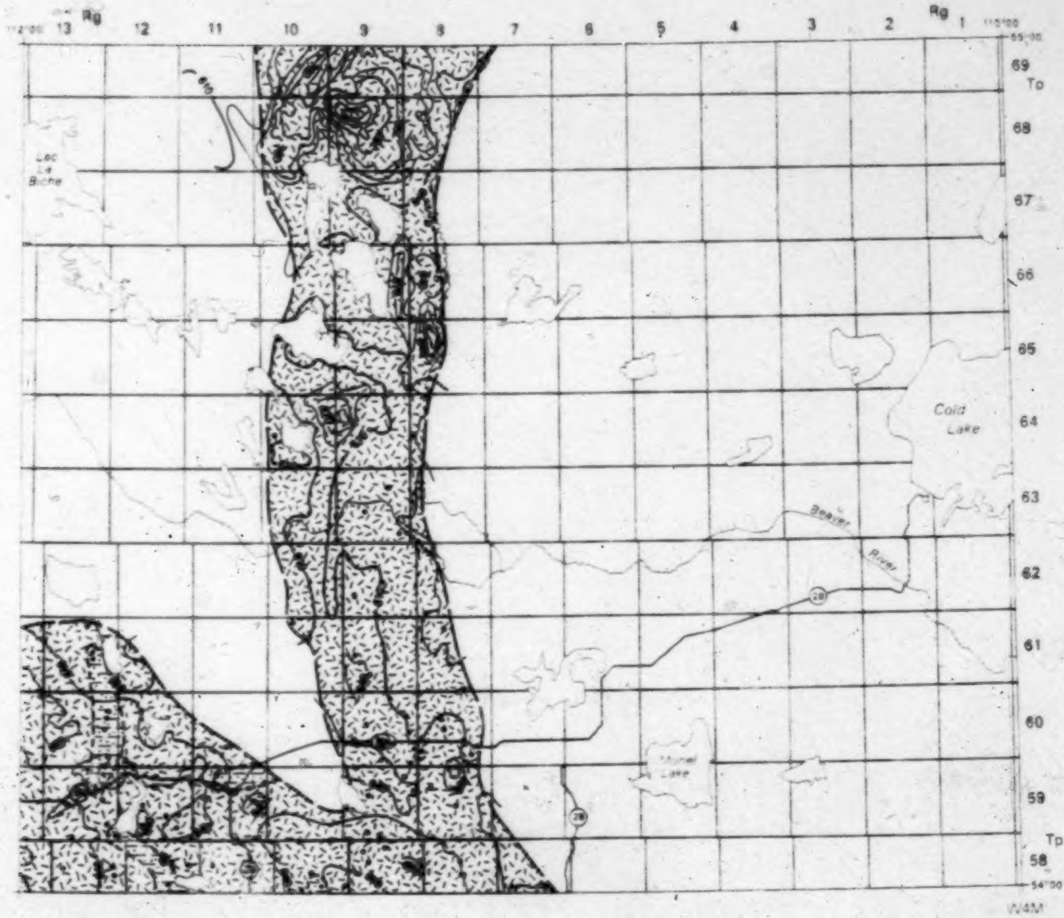
X - Mean
S.D. - Standard Deviation

Only one sample of the Kehiwin Lake Member was analysed for the clay mineralogy, and that contained about 58% illite, 22% kaolinte, 15% montmorillonite, and 5% chlorite (Appendix B).

Glacially streamlined landforms on the surface of the Kehiwin Lake Member have a characteristic north-south orientation (Figure 43).

Distribution, Thickness, and Topography

The Kehiwin Lake Member outcrops along an approximately 20 km wide strip in the central part of the map area, extending from the Seibert Lake Upland in Tp 69, south to the Kehiwin Upland Plain in Tp 58 (Figure 54). The member is believed to extend southwest of the map area and has been mapped within the subsurface in the Vilna and Saddle Lake Plains, and the Saddle Lake Upland (Figure 9, x-secs E4-E4' and N1-N1'). The eastern boundary of the member essentially parallels the course of the Sand River in the north, and the Kehiwin Lake in the south. The top of the member ranges in elevation from as high as 850 m within the Heart Lake Highland to as low as 590 m within the Kehiwin Upland Plain (Figure 54). The Kehiwin Lake Member is one of the thickest stratigraphic units in the map area, averaging more than 30 m over most of its extent (Figure 9, x-sec N1-N1' and N2-N2', and Figure 55). The member ranges in thickness from as much as 60 m in Tps 60-63, Rg 9, to as little as 3 m near the reference section in Tp 60, Rg 8. Large areas of thick deposits are mapped within the Kehiwin Upland Plain where the great thickness produces the high relief which defines the western limit of the Beaver River Lowland Plain (Figure 9, x-sec N1-N1'). Other thick deposits are mapped within isolated, large scale glacially streamlined landforms, located in Tps 65-66, Rg 8 (Fenton and Andriashek, 1983). The member is believed to thin along both the eastern edge where it overlies the Reita Lake Member, and along the western edge where it is overlain by the Vilna Member. The sand and gravel, which overlies the diamicton in the southwest corner of the map area, is generally less than 7 m thick and appears to lie within a poorly defined meltwater channel eroded onto the surface of the diamicton of the Kehiwin Lake Member (Figure 9, x-sec E4-E4').



Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg 1
112°00
110°00
55°00
54°00
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
W4M
Lac La Biche
Cold Lake
Beaver River
Muriel Lake
28

Figure: 54 Elevation of the upper surface of the Kehiwin Lake Member.

Note the stratified deposits which lie in a poorly defined channel on the surface of the diamicton in townships 58 to 61, ranges 12 to 13.

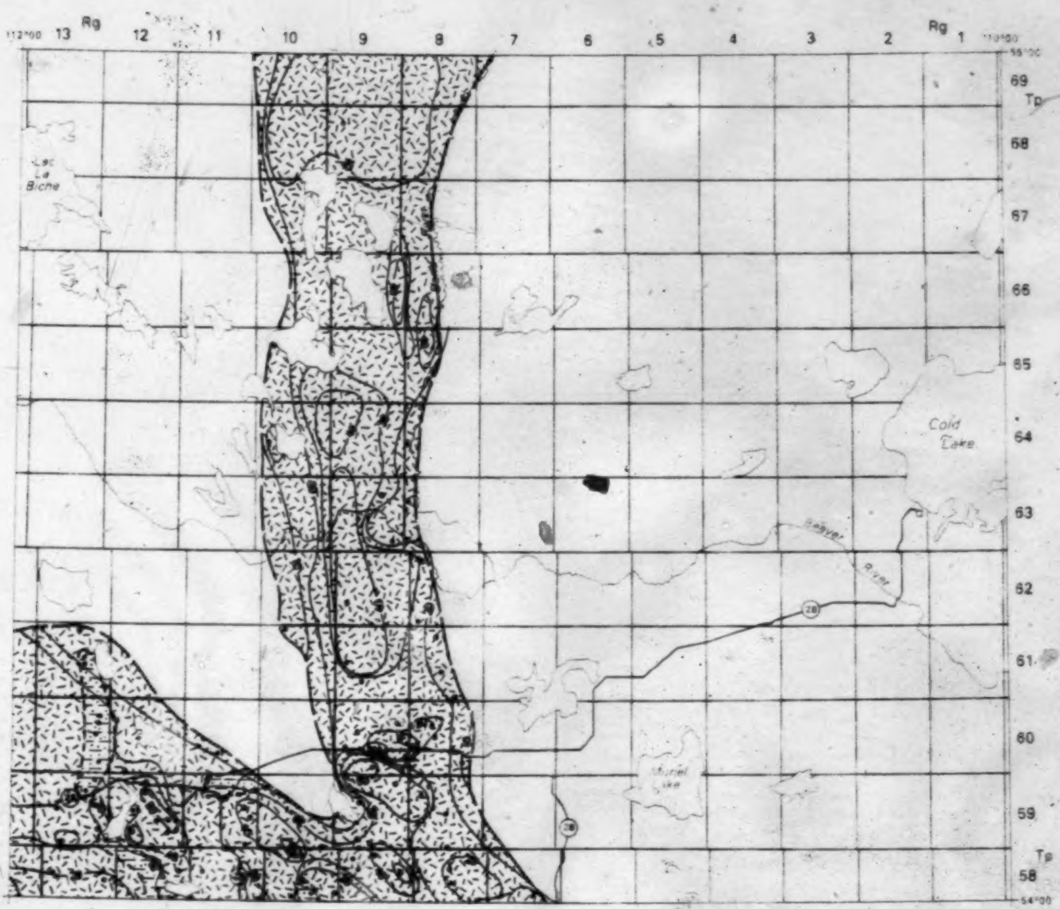
▨ Sand and Silt

▨ Diamicton (till)

Unit Boundaries:
Approximate.................. ——— ———
Assumed...................... — — — — —

Contours, Interval 30 metres:
Defined...................... ——900——
Approximate.................. — —900— —

Data Location.................. •


112°00
Rg
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Rg
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110°00
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Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00
W4M
Lac La Biche
Cold Lake
Beaver River
Muriel Lake
28

Figure: 55 Total thickness of diamicton and stratified sediment in the Kehiwin Lake Member.

Note the extensive, thick deposits near the eastern boundary of the member.

▤ Sand and Silt

▨ Diamicton (till)

Unit Boundaries:

Approximate.................. — — —

Assumed.................. - - - - - -

Isopach, Interval 10 metres............. ═50═

Data Location........................ •

Differentiation from other units

The differentiation between the Kehiwin Lake Member and the Reita Lake Member is discussed in the previous section. The Kehiwin Lake Member is differentiated from the Vilna Member by the following:

1. The Kehiwin Lake Member is stratigraphically lower and, except for the central part of the map area, is overlain by the Vilna Member (Figure 9, x-sec N1-N1').
2. The Kehiwin Lake Member is considerably more sandy than the Vilna Member (Table 2).
3. The Kehiwin Lake Member contains more quartz and less igneous and metamorphic fragments than the Vilna Member (Table 2).
4. The Kehiwin Lake Member has a lighter olive-brown color compared to the dark grey-brown color of the Vilna Member.
5. Glacially streamlined landforms on the surface of the Kehiwin Lake Member are oriented in a north-south direction, whereas those of the Vilna Member are oriented northwest-southeast (Figure 43).

The Kehiwin Lake Member may be difficult to differentiate from the Marie Creek Formation in the field because both units have a similar oxidized olive-brown color, both are sandy, and both have a highly fractured, blocky structure. The two are differentiated by the following analytical properties:

1. The Marie Creek Formation contains more pebbles, granules and coarse sand than does the Kehiwin Lake Member (Table 2).
2. The Kehiwin Lake Member contains significantly less carbonate, particularily dolostone, in the coarse sand and silt-clay fractions compared to the Marie Creek Formation (Table 2).

Similarily, the Kehiwin Lake Member may be difficult to differentiate from the Bonnyville Formation, because both units are sandy in the central part of the map area, both contain few carbonates, and both have a relative abundance of quartz in the very coarse sand fraction (Table 2, and Figure 8, x-sec E3-E3'). The two units are differentiated however, by the following:

1. In the central part of the map area the Kehiwin Lake Member is less sandy than the Bonnyville Formation, particularily in the amount of very coarse sand (Table 2). In the

west the reverse is true - the Kehiwin Lake Member is significantly more sandy than the Bonnyville Formation.

2. The Kehiwin Lake Member generally contains less quartz in the very coarse sand fraction than the Bonnyville Formation, though locally, both units have a similar amount (Figure 57, testhole 77SR-7).

Nature of Contacts

Lower Contact

The contact between the Kehiwin Lake and Reita Lake Members is discussed in the previous section. The contact of the Kehiwin Lake Member with the underlying Sand River Formation is sharp and is considered to be disconformable (Appendix A, testhole 77SR-16). Possibly, some of the numerous sand lenses within the Kehiwin Lake diamicton near the type section, may consist of "clasts" of the underlying Sand River Formation which have been glacially eroded and incorporated into the member. The contact between the Kehiwin Lake Member and the Marie Creek Formation is generally sharp, though in places the contact can be texturally and compositionally gradational (Appendix A, testhole 77SR-9). The contact is considered to be disconformable. In the southwest, where the Kehiwin Lake Member directly overlies the Bonnyville Formation, the contact is sharp and well defined from both the analytical data, (Appendix A, testhole 77SR-1) and the resistivity responses (Figure 9, x-sec E4-E4' testhole E439). In the south-central part of the map area in Tps 58-60, Rgs 8-10, both units are texturally similar, and the contact can be sharp, (Appendix A, testhole 77SR-3) or, gradational and difficult to recognize (Appendix A, testhole 77SR-2).

Upper Contact

The Kehiwin Lake Member is exposed along a narrow band in the central part of the map area (Figure 43). In the southwest part of the map area the Kehiwin Lake Member is overlain by the Vilna Member and for the most part the contact is generally sharp and well defined (Appendix A, testholes 77SR-3 and 77SR-15), even though in places the two are texturally gradational (Appendix A, testhole 77SR-7).

The contact is very well defined in that part where the Vilna Member overlies stratified sediment of the Kehiwin Lake Member (Figure 9, x-sec E4-E4', and Appendix A, testholes 77SR-3, 77SR-7, and 77SR-15). In the central part of the map area the contact is more difficult to define because the two members interfinger and form a gradational lateral contact (Appendix A, 77SR-16). This suggests that the contact is conformable.

Origin and variations in the till properties

Diamicton of the Kehiwin Lake Member represents glacial sediment (till) which was deposited by the Seibert Lobe during the advance of the Cold Lake Glacier. On the basis of flute and drumlin orientations, the Seibert Lobe advanced due south in the central part of the map area (Figure 43). Extensive glacial ice-thrusting occurred in the north as the lobe advanced southward. This eroded the Spencer Lake, Touchwood Lake, Seibert Lake and possibly Pinehurst Lake basins.

It is almost certain that the eastern margin of the Seibert Lobe was in contact with the southwestward flowing Primrose Lobe. Two lines of evidence support this. Firstly, a southwest oriented flute on the surface of the Reita Lake Member in Tp 61, Rg 8, curves southward, indicating that it was deflected by ice flowing from the north, the Seibert Lobe (Figure 43). This indicates that not only were the two lobes confluent for some time in this area, but that the westward advance of the Primrose Lobe likely was restricted by the Seibert Lobe. Secondly, though less direct, is the fact that the Seibert Lobe must have had a confining ice margin along its eastern boundary, otherwise it would have flowed eastward into the lower elevation of the Beaver River Lowland Plain. The glacial flow indicators show no such evidence of ice flow to the east, which indicate that the eastern margin was bounded by ice of the Primrose Lobe.

Fenton and Andriashek (1983) show that the contact between the Primrose and Seibert Lobes is generally well defined on the basis of the morphology of the surface landforms. However, the ice of these two lobes must have interfingered, as evidenced by the interfingering, gradational contact between the Kehiwin Lake and Reita Lake tills (Appendix A, testholes 77SR-18, 77SR-19).

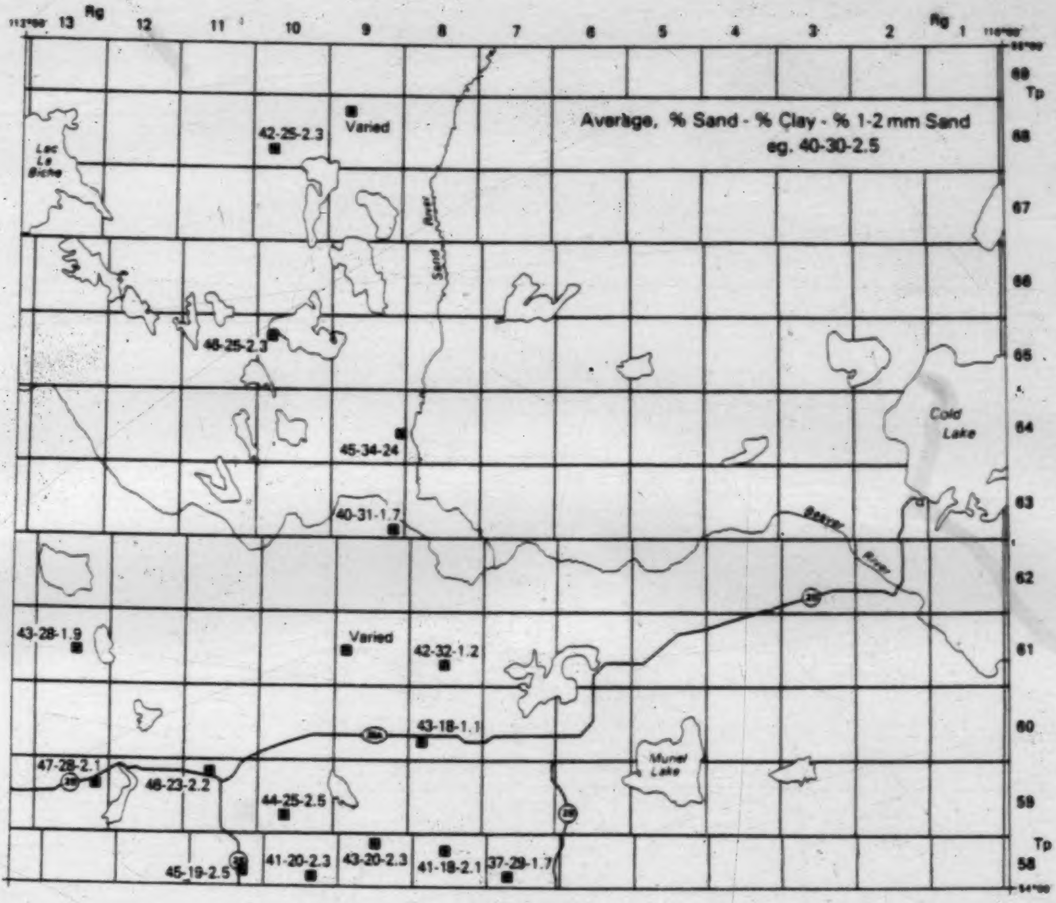
The southward flow of the Seibert Lobe likely extended across the entire west half of the map area and into the Tawatinaw and Vermilion map areas. This interpretation is based on the following. Firstly, the sandy till of the Kehiwin Lake Member can be mapped from the central part of the map area into the extreme southwest corner, even though it is buried in the southwest by the Vilna Member (Table 10 and Figure 9, x-sec N1-N1'). Secondly, south of Vilna in Tp 59, Rg 13, a buried glacial flute, likely on the surface of the buried Kehiwin Lake Member, is oriented in essentially a north-south direction (Figure 43). This orientation is similar to that of the flutes on the surface of the Kehiwin Lake Member in the central part of the map area (Figure 43). Thirdly, the east-west orientation of the ridges in the thrust moraines within the Whitefish Lake Highland and south of Saddle Lake, indicates glacial thrusting from a northerly source, the same source direction of the Seibert Lobe (Fenton and Andriashek, 1983).

During the retreat phase of the Seibert Lobe in the far southwest corner of the map area, glacial meltwater deposited sand and gravel within a poorly defined channel which was eroded on the surface of the Kehiwin Lake till (Figure 54). These stratified deposits were subsequently buried by till of the Vilna Member, deposited by the Lac LaBiche Lobe.

Figure 56 shows that the Kehiwin Lake Member is generally sandy throughout. The origin the sandy till of the Kehiwin Lake Member is not certain, but it may reflect glacial erosion and incorporation of underlying sandier units. The evidence for this is that sand lenses are commonly interbedded with the till near the type section and within many outcrops cut into the glacially streamlined ridges on the surface of the member. It is believed that these lenses were not deposited in situ, but rather, represent glacially eroded masses of older sediment, possibly stratified sediment of the Sand River Formation.

Minor textural variations within the Kehiwin Lake Member are found along the eastern and western margins of the zone of outcrop. Here, the Kehiwin Lake Member is more clayey as a result of its gradational contact with the Reita Lake and Vilna Members.

Some variations are shown in the composition of the very coarse sand fraction, especially in the ratio of igneous-metamorphic fragments to quartz fragments. For example, in testhole 77SR-4 (Table 10) the Kehiwin Lake till contains about 66% igneous-metamorphic rocks and 27% quartz; nearby testhole 77SR-7 (Table 10) on the


112°00'
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Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00'
Average, % Sand - % Clay - % 1-2 mm Sand
eg. 40-30-2.5
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
42-25-2.3
Varied
46-25-2.3
45-34-24
40-31-1.7
43-28-1.9
Varied
42-32-1.2
43-18-1.1
47-28-2.1
46-23-2.2
44-25-2.5
45-19-2.5
41-20-2.3
43-20-2.3
41-18-2.1
37-29-1.7
28
28A
36
28

Figure: 56 Regional variations in the textural properties of the Kehiwin Lake Member.

other hand, contains only 57% igneous-metamorphic rocks, and as much as 35% quartz, a a difference of almost ten percent. In fact, in places this relative increase of quartz and decrease in igneous-metamorphic rock fragments results in the composition of the very coarse sand fraction of the Kehiwin Lake till being very similar to that of the underlying Bonnyville Formation. This suggests that the Kehiwin Lake till may have been derived from the erosion and incorporation of the underlying Bonnyville Formation.

Another possible explanation for the similarilty, in places, between the lithic composition of the Kehiwin Lake till and the Bonnyville till is that both units had a similar type of sand source. In the case of the Bonnyville Formation, it overlies, and may have incorporated, sand and gravel of the Muriel Lake Formation; in the case of the Kehiwin Lake Member, it overlies, and may have incorporated, sand of the Sand River Formation.

D. Grand Centre Formation: Vilna Member

Source of Name: The town of Vilna, Alberta located in Tp 59, Rg 13, W4M in the southwest corner of the Sand River map area, NTS 73L.

Type Section: Alberta Geological Survey auger testhole 77SR-7, located in LSD 16, Sec 29, Tp 59, Rg 11, W4M in the Sand River map area, NTS 73L (Figure 57). At this location the Vilna Member overlies the Kehiwin Lake Member.

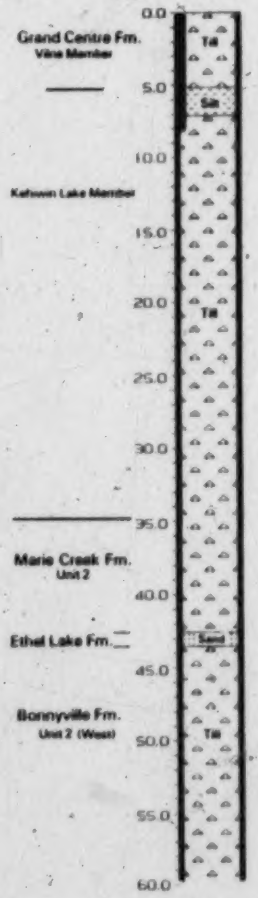
Type Area: The area southeast of the type section, within the Ashmont and Mallaig region (Tps 58-59, Rgs 9-11), in the Sand River map area, NTS 73L.

Reference Sections: The top of the member is exposed in a road cut in LSD 4, Sec 29, Tp 61, Rg 10, W4M. Complete sections of the member are mapped in Alberta Geological Survey auger testholes 77SR-3 (LSD 16, Sec 10, Tp 58, Rg 10, W4M), 77SR-4 (LSD 13, Sec 14, Tp 58, Rg 11, W4M), 77SR-10 (LSD 1, Sec 33, Tp 58, Rg 9 W4M), and 77SR-15 (LSD 9, Sec 15, Tp 61, Rg 13 W4M).

77 SR 7

Alberta Geological Survey Testhole 77 SR 7
Location NE of LSD 16 Sec 29 Twp 59 Rng 11 W of 4 Mer . NTS 73L
Elevation 2130 Ft. 649 M Source 1:50,000 NTS 73L/4
Date drilled 197707 27 Logged by ANDRIASHEK

NOTE:
Heavy Bar Denotes Oxidized Profile



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								23.3				68.0	28.7	2.5	0.0	0.0	0.7	0.0	275
2.00	26.9	23.8	49.3	29.2	31.6	39.3	1.16	14.9				64.3	30.8	0.7	2.1	1.4	0.7	0.0	143
3.00	29.3	29.6	41.1	31.8	36.1	32.1	0.00	10.7				59.6	35.1	0.3	2.6	1.7	0.6	0.0	347
4.00	30.9	32.4	36.7	33.3	38.4	28.3	1.32	18.1				66.7	19.6	2.0	3.9	3.9	3.9	0.0	51
5.00	42.1	27.4	30.5	44.7	31.3	24.0	2.08	10.8				65.6	30.3	0.3	1.4	1.7	0.7	0.0	284
6.00								12.3				56.1	39.5	0.0	2.6	1.7	0.0	0.0	114
7.00	46.5	23.2	30.3	49.2	27.0	23.8	2.47	10.9				61.0	30.9	1.2	1.5	4.0	1.2	0.0	323
8.00	48.5	22.9	28.6	51.1	26.0	22.9	2.46	11.7				58.3	31.9	1.0	3.7	3.2	2.0	0.0	408
9.00	49.6	22.7	27.7	52.3	26.2	21.5	2.58	10.2				57.2	38.8	0.6	0.0	1.6	1.6	0.0	484
10.00								10.1				59.4	33.7	0.8	0.8	3.3	1.9	0.0	362
11.00	45.6	30.4	24.0	48.3	35.3	16.4	2.35	10.5				62.1	29.0	1.0	2.9	4.2	0.5	0.3	383
12.00								10.3				59.5	32.0	0.8	3.6	1.3	2.8	0.0	390
13.00	47.3	31.6	21.1	50.0	35.9	14.2	2.01	12.0				56.8	33.8	0.3	3.6	4.2	1.3	0.0	308
14.00								9.4				56.9	35.9	1.3	0.3	1.0	1.0	0.0	295
15.00	49.2	31.0	19.8	51.9	35.5	12.7	2.20	12.6				56.9	36.6	0.0	3.2	3.2	1.0	0.0	311
16.00								10.0				58.0	33.3	1.1	2.9	3.3	1.4	0.0	276
17.00	48.7	30.7	20.6	51.4	35.5	13.0	1.96	9.3				59.9	30.9	0.3	3.7	3.4	1.5	0.0	324
18.00								11.8				63.8	29.8	0.3	1.3	2.6	1.6	0.6	312
19.00	49.6	26.7	23.6	52.3	32.0	15.7	2.30	9.9				61.4	36.3	0.0	1.1	0.4	0.7	0.0	267
20.00								9.6				59.0	31.9	0.3	2.8	2.5	3.1	0.3	354
21.00	47.9	26.9	25.2	50.5	32.4	17.1	2.12	11.0				54.2	36.7	0.4	3.4	2.7	2.3	0.2	441
22.00								10.4				55.4	37.2	0.3	3.3	3.0	0.8	0.0	368
23.00	47.2	29.2	23.6	49.9	34.4	15.7	2.02	10.1				54.9	37.1	0.3	2.9	2.4	2.1	0.3	377
24.00								11.2				53.1	35.7	0.9	4.2	4.2	1.5	0.3	333
25.00	47.2	27.5	25.3	50.5	32.0	17.5	1.78	11.6				55.3	37.9	0.5	1.9	2.2	2.2	0.0	367
26.00								11.7				58.0	33.3	0.7	5.3	1.7	1.0	0.0	300
27.00	49.0	26.8	24.2	51.8	32.9	15.3	1.81	10.5				56.1	34.9	0.7	3.9	2.8	1.4	0.2	433
28.00								10.7				57.8	36.1	0.7	3.2	0.7	1.4	0.2	438
29.00	47.7	28.4	23.9	50.8	33.2	15.9	2.20	10.3				56.1	33.2	0.7	3.8	4.9	1.2	0.0	424
30.00								10.6				54.1	38.9	0.7	3.6	2.7	0.0	0.0	442
31.00	46.0	31.4	22.7	48.7	36.4	14.9	2.20	10.9				57.6	34.3	0.5	4.6	1.4	1.6	0.0	434
32.00								10.7				55.1	37.6	0.9	3.8	2.0	0.7	0.0	452
33.00	47.3	30.0	22.6	50.4	35.0	14.6	2.35	10.9				53.4	38.5	0.9	3.4	2.5	1.3	0.0	442
34.00								10.4				55.3	34.9	0.8	3.2	4.9	0.8	0.0	473
35.00	50.2	30.8	18.9	53.0	34.7	12.4	2.53	10.2				64.3	29.0	1.0	0.7	3.5	1.0	0.3	286
36.00								10.1				62.1	30.1	1.0	2.3	4.0	0.4	0.0	472
37.00	42.5	28.4	29.1	44.9	34.8	20.3	2.17	9.3				63.4	28.8	0.6	1.8	4.2	1.0	0.2	500
38.00								10.5				59.3	32.6	1.9	1.9	3.2	1.1	0.0	374
39.00	39.8	27.6	32.6	42.2	32.9	24.9	2.12	10.1				61.6	26.1	1.6	2.7	6.8	1.8	0.0	383
40.00								10.4				63.3	27.6	0.8	1.9	5.6	0.8	0.0	376
41.00	39.9	30.2	29.9	42.4	36.7	20.9	2.06	10.6				61.6	26.7	1.1	3.3	5.5	1.5	0.2	453
42.00								10.4				63.1	23.1	1.5	3.7	6.5	1.8	0.3	325
44.00	29.4	39.8	30.8	32.2	47.0	20.8	1.42	12.8				48.9	36.4	0.7	6.9	4.2	2.4	0.3	288
45.00								12.9				44.7	43.1	0.0	4.5	4.9	2.6	1.1	266
46.00	32.5	37.9	29.6	35.7	44.8	19.4	1.60	11.9				56.5	35.2	0.7	4.3	0.3	2.5	0.3	273
47.00								11.7				54.4	31.8	0.3	4.5	4.2	4.2	0.5	377
48.00	39.0	34.8	26.2	39.8	43.1	17.1	1.23	13.3				51.2	35.6	2.7	1.9	3.5	4.8	0.3	371
49.00								11.5				51.0	40.0	0.7	3.2	2.9	2.4	0.0	410
50.00	33.2	35.2	31.6	35.9	42.9	21.2	1.39	12.2				51.5	39.7	0.5	4.4	1.9	1.6	0.0	365
51.00								12.5				49.0	40.3	1.1	4.2	2.7	2.3	0.4	263
52.00	31.3	33.1	35.5	34.1	41.8	24.2	1.27	12.7				51.7	37.6	0.4	5.2	2.6	1.8	0.7	271
53.00								10.8				57.2	36.4	1.2	1.8	0.9	2.1	0.3	332
54.00	40.6	31.3	28.1	43.1	38.8	18.1	2.06	11.3				53.1	38.2	0.7	4.2	3.5	1.2	0.0	424
55.00								13.4											
56.00	39.1	29.4	31.5	41.9	37.2	20.9	1.53	10.8				56.0	35.6	1.6	3.1	2.3	1.3	0.0	282
57.00								11.6				52.3	35.5	0.6	6.0	2.0	3.4	0.0	352
58.00	38.1	38.2	23.7	40.6	44.2	15.1	1.59	11.9				56.4	36.9	0.5	1.7	2.5	1.8	0.0	358
59.00	38.5	32.0	29.5	41.3	39.1	19.6	1.52	11.5				61.4	32.1	1.2	2.2	1.5	1.2	0.2	324
60.00	36.1	39.1	24.8	38.8	45.9	15.3	1.35	10.9				59.7	32.8	0.9	2.8	1.8	1.8	0.0	323

Figure:57 Type section of the Vilna Member of the Grand Centre Formation. Alberta Geological Survey testhole 77SR 7 (LSD 1 Sec 29 Tp 59 Rg 11 W4M).

Description of Unit

The Vilna Member consists of a clayey diamicton, which in places includes blocks of glacially displaced older sediment. The member forms the surface unit in the west part of the map area, and has been mapped from both outcrops and testhole samples. The top of the Vilna Member is oxidized dark grey-brown (2.5 Y 4 / 2) which becomes unoxidized very dark grey (5Y 3 / 1) with depth.

In outcrop the diamicton is commonly very clayey, and contains few pebbles or granules. Generally the diamicton is massive though in places it has a psuedostratified appearance. These "strata" generally consist of older sediment has glacially displaced and attenuated in the form of layers or beds within the diamicton (Plate 6).

The average matrix texture of the diamicton, consists of about 32% sand, 32% silt, and 36% clay, with very coarse sand making up about 1% of the matrix (Table 2). The textural variations range between 20% to 40% sand, 30% to 40% silt, and 25% to 50% clay (Table 11). The clayey texture is also expressed by a relatively high moisture content of about 13%, and this, combined with an unconsolidated nature, results in the unit being soft and easy to penetrate with a dry auger.

The average composition of the very coarse sand fraction consists of about 64% igneous and metamorphic rock fragments, 28% quartz, <1% quartzites and quartz sandstone fragments, 3% limestone, 3% dolostone, and 1% locally derived bedrock fragments (Table 2). The variations range between 55% to 79% igneous and metamorphic fragments, 18% to 32% quartz, 0% to 6% quartzite and quartz sandstone fragments, 1% to 4% limestone, 2% to 6% dolostone, and .5% to 3% locally derived bedrock fragments (Table 11).

Calcareous material makes up about 11% of the silt-clay fraction, with dolomite more abundant than calcite (calcite / dolomite ratio = .33, Table 2).

The clay mineralogy of a few samples from one testhole consists of about 53% illite, 21% kaolinite, 17% montmorillonite, and 9% chlorite (Appendix B).

Glacially streamlined landforms on the surface of the Vilna Member are very pronounced and have a dominant northwest-southeast orientation (Figure 43).

Table 11. Properties of the Vilna Member of the Grand Centre Formation. Table depicts average values of the properties from each testhole in which the unit is recognized.

Testhole	Location LSD-Sec-Tp-Rg-M	n	Properties of Matrix Texture Sand % X	 Sand % S.D.	 Clay % X	 Clay % S.D.	 1-2 mm Sand % X	 1-2 mm Sand % S.D.	 Moisture % X	 Moisture % S.D.	1-2 mm Coarse Sand Mineralogy Igneous Metam. % X	 Igneous Metam. % S.D.	 Qtz. % X	 Qtz. % S.D.	 Lst. % X	 Lst. % S.D.	 Dol. % X	 Dol. % S.D.	 Qtzite & Qtz. Sst. % X	 Qtzite & Qtz. Sst. % S.D.	 Local % X	 Local % S.D.	Matrix Carbonate CO₂ % X	 CO₂ % S.D.	 Calcite Dolomite % X	 Calcite Dolomite % S.D.
77SR3	16-10-58-10-W4M	5	36	3	25	3	1.6	2	14	1	66	2	27	1	2	1	3	1	1.0	.5	.6	.4	11	3	33	.1
77SR4	13-14-58-11-W4M	6	34	4	27	3	1.1		13	1	71		23	2	2	1	3	1	1.0	.7	.8	.3				
77SR5	3-26-58-13-W4M	2	38	-	37		1.5		17	2	61	4	30	5	3	1	2	1	.3	.4	.3	.2				
77SR6	9-23-58-13-W4M	22	Mixed tills - Highly variable properties																							
77SR7	16-29-58-11-W4M	5	29	2	39	3	1.2	1	15	3	65	3	31	3	3	1	2	1	1.2	1.0	.7	.1				
77SR8	11-25-61-11-W4M	20	33	3	38	3	1.1	2	13	1	59	3	31	3	3	2	4	2	1.3	.7	1.2	.8				
	Thrust Marie Creek Till																									
		4	32	1	32	4	1.9	1	10	1	57	2	27	2	3	1	11	2	.6	.4	1.5	.5				
		8	28	5	35	3	.7	1	12	1	63	6	29	4	3	1	4	2	1.4	1.0	1.2	.8				
77SR10	1-33-58-9-W4M	11	33	3	33	5	1.4	2	11	1	68	2	24	2	3	1	3	1	.8	.4	1.6	.6				
77SR12	1-15-60-10-W4M	22	34	2	41	4	1.2	1	12	1	58	3	32	2	3	1	3	1	1.2	.8	1.4	.8				
	Thrust Marie Creek Till	6	38	2	36	3	2.7	1	10	0	64	4	28	4	2	1	5	0	.1	.1	.6	.4				
		8	25	2	51	2	1.6	1	12	1	62	3	28	1	3	1	6	-	.1	.2	1.6	.6				
77SR15	9-15-61-13-W4M	9	39	2	30	3	1.6	2	11	4	72	4	23	3	1	1	2	1	.9	.6	.5	.5				
77SR16	9-18-61-9-W4M	2	26	2	38	1	1.0	2	12	1	62	1	31	3	2	1	4	1	1.7	.8						
77SR20	1-25-63-11-W4M	7	29	3	42	1	.8	1	22	1	56	4	32	3	2	1	3	1	2.2	.8	1.6	1.0				
	Thrust Marie Creek Till	5	56	6	21	8	1.5	4	9	1	54	2	30	4	5	2	6	1	3.7	2	.5	.3				
		7	32	2	36	3	1.2	2	9	1	64	4	28	3	2	1	3	1	1.4	.3	.9	.5				
77SR21	10-18-63-12-W4M	18	33	3	37	3	1.1	4	15	1	62	3	29	4	3	1	3	1	1.5	.7	1.8	.8				
77SR22	3-30-64-13-W4M	2	43		27	-	1.8		14	1	43	2	25	3	10	1	16	1	6.3	.8	.8	.4				
	Thrust Marie Creek Till																									
		10	33	2	34	1	1.3	2	13	1	64	3	26	2	2	1	4	1	2.0	1.0	1.7	.9				
77SR24	9-19-66-12-W4M	4	29	4	35	2	.5	.3	15	2	56	3	32	3	3	2	5	2	2.2	1.0	1.2	1.1				
77SR26	2-8-68-10-W4M	1									79	-	18	-	2	-	3	-	.4		.4	-				
77SR27	2-38-67-12-W4M	23	25	8	36	4	.7	3	14	2	68	5	23	4	4	2	3	2	2.4	.9	2.1	1.2				
77SR28	10-22-69-11-W4M	9	21	1	48	4	.8	.1	8	1	64	4	29	2	3	1	2	1	1.3	.7	1.4	1.0				
77SR29	8-2-69-13-W4M	6	35	2	32	4	1.9	.4	11	1	69	3	23	2	3	1	2	1	.3	.2	2.1	.8				
77SR31	2-31-68-13-W4M	3	29		35	1	1.5	.1	11	1	61	1	32	1	2	-	3	1	.7	.1	.5	.2				
Mean of the mean values from all testholes			32	4	38	6	1.2	.4	13	3	64	5	28	4	3	1	3	1	1.2	.7	1.3	.7	11	3	33	1
Total number of samples -n			n = 176		n = 176		n = 176		n = 176		n = 176		n = 176		n = 176		n = 176		n = 176		n = 176		n = 5		n = 5	
Total number of testholes -N			N = 19		N = 19		N = 19		N = 19		N = 19		N = 19		N = 19		N = 19		N = 19		N = 19		N = 1		N = 1	

X - Mean
S.D. - Standard Deviation

Distribution, Thickness and Topography

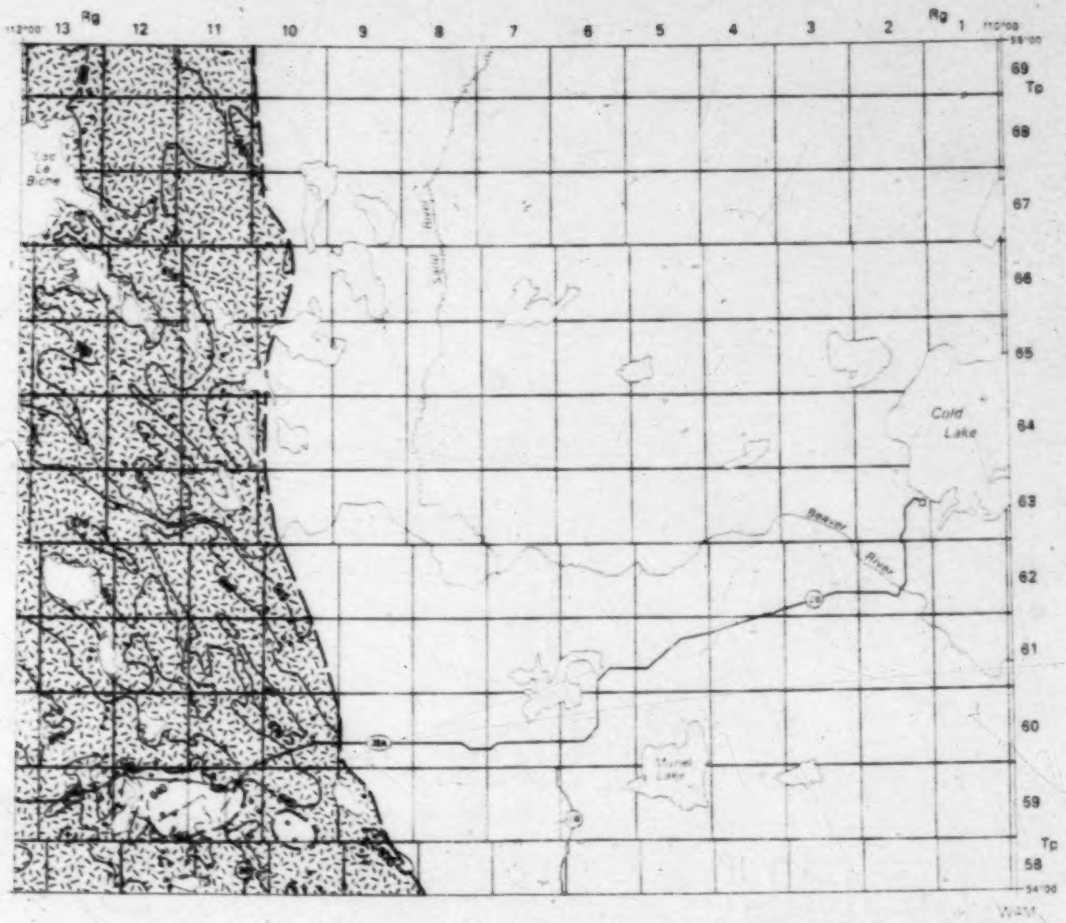
The Vilna Member forms the surface unit over most of the west part of the Sand River map area (Figure 58). It is absent only in number of isolated areas within Tps 58 to 60, Rgs 9 - 13, where the underlying Kehiwin Lake Member is exposed. The eastern limit of the Vilna Member lies essentially along Rg 10, extending south from Tp 69 to Tp 58. This boundary is not clearly defined, primarily because along its eastern edge the Vilna Member is gradational or interfingers with the Kehiwin Lake Member. In fact, the geomorphology of the surface of the Vilna Member is most useful for establishing the eastern boundary. In the north the limit is defined by a hummocky, interlobate moraine in the Seibert Lake Upland (Fenton and Andriashek, 1983); in the south the limit is defined by the intersection of the northwest-southeast oriented streamlined landforms of the Vilna Member, with the north-south oriented landforms of the Kehiwin Lake Member.

The Vilna Member extends west and south out of the study area and into the Tawatinaw and Vermilion map areas (Figure 9, x-secs E4-E4' and N1-N1'). The top of the Vilna Member ranges in elevation from as high as 700 m within a large glacial ice-thrust moraine in the Garner Lake Upland, to as low as 550 m within the area bordering Lac LaBiche.

The thickest deposits are found within isolated areas in the southwest (Tp 58, Rg 13; Tp 62, Rg 14; Tps 60-61, Rgs 11-12) and, along the southeast border of the unit (Figure 59). Within these areas the member is as much as 40 m thick in places. Thin deposits of the Vilna Member are found in the area bordering Lac LaBiche and near Imperial Mills in Tps 67-69, Rgs 12-13 (Figure 59). Here the member is commonly less than 9 m thick. Notably, thin deposits are also mapped in the extreme southwest corner of the map area in Tps 58-61, Rgs 13-14, where the Vilna Member forms a thin to discontinuous drape overtop the Kehiwin Lake Member (Figure 9, x-sec E4-E4').

Differentiation from other units

Stratigraphically the Vilna Member forms the surface unit over most of the western part of the map area. It overlies the Kehiwin Lake Member in the southwest corner and older formations in the west-central and northwest corner (Figure 9). Table 2 shows that the Vilna Member is more clayey and less sandy than the Kehiwin Lake Member.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63
62
61
60
59
Tp
58
54°00'
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
W4M

Figure: 58 Elevation of the upper surface of the Vilna Member.

▨ Diamicton (till) and Displaced Sediment

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - - - -
Contours, interval 30 metres:
Defined 550
Approximate 550
Data Location .... •

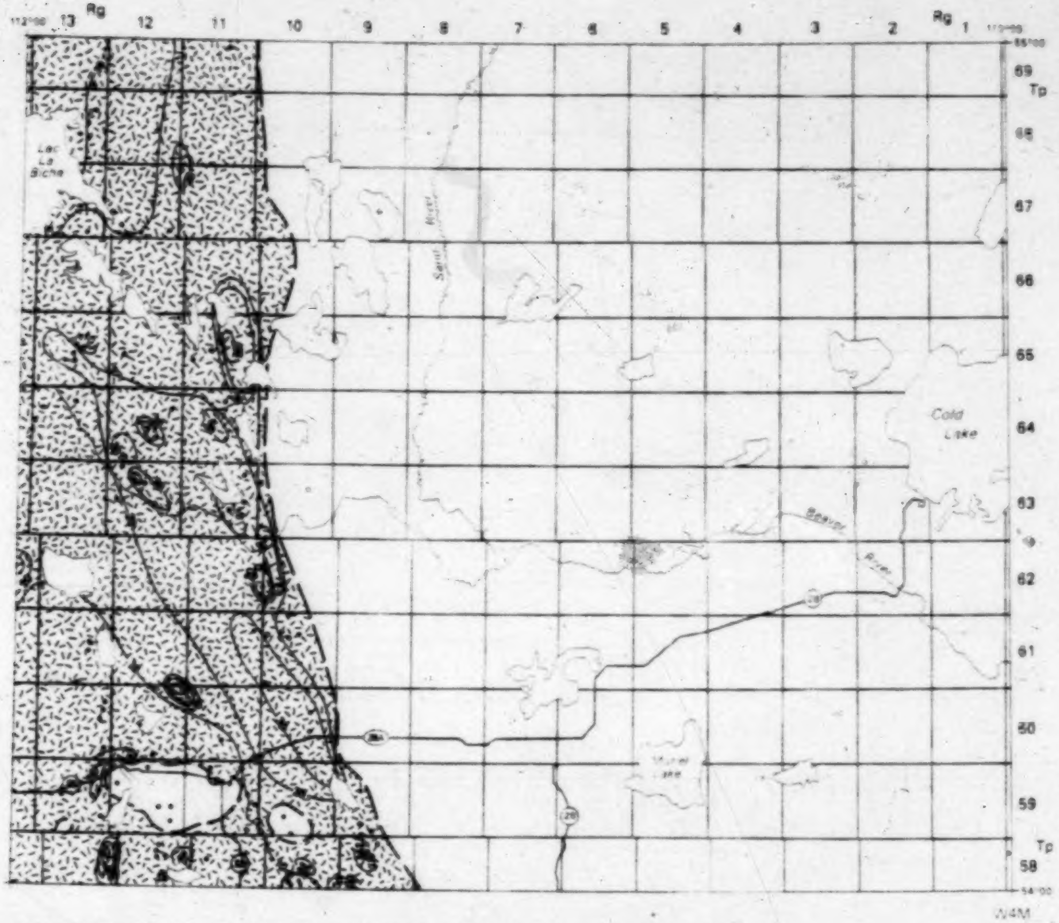

Rg
13
12
11
10
9
8
7
6
5
4
3
2
Rg
1
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
Lac La Biche
Sand River
Cold Lake
Beaver River
Muriel Lake
W4M

Figure: 59 Thickness of diamicton and glacially displaced sediment in the Vilna Member.

Note the thick deposits which extend from Lac LaBiche, southeast to township 59, range 10.

▨ Diamicton (till) and Displaced Sediment

Unit Boundaries:
Approximate .... — — —
Assumed .... - - - - -
Isopach, interval 10 metres .... ═══ 10 ═══
Data Location .... •

In outcrop it has a darker grey brown color, compared to the olive-brown color of the Kehiwin Lake Member. Within certain areas the composition of the very coarse sand fraction may also be useful to differentiate these two members: in a number of locations the Vilna Member contains significantly more igneous and metamorphic fragments and less quartz than does the Kehiwin Lake Member (Tables 10 and 11, testholes 77SR-10 and 77SR-15).

Differences in the geomorphology of the surface landforms of both members, particularily in the orientation of glacially streamlined features, enable the two members to be easily differentiated. Flutes and drumlinoid ridges of the Vilna Member are oriented northwest-southeast whereas those of the Kehiwin Lake Member are oriented north-south (Figure 43). The intersection of these oriented landforms essentially defines the lateral contact between the two members.

Although the lithologic and compositional properties of the Vilna and Reita Lake Members are similar (Table 2), the two can be differentiated by geographic and stratigraphic position as well as differences in orientation of glacially streamlined landforms. The Vilna Member lies in western part of the map area and is separated from the Reita Lake Member, both laterally and vertically, by the Kehiwin Lake Member. Glacially streamlined features on the surface of the Reita Lake Member are oriented in a southwest direction, essentially orthogonal to those of the Vilna Member.

The Vilna and Hilda Lake Members are also similar in composition (both are clayey and both contain significant amounts of glacially displaced masses of older sediment), but the two can be differentiated on the basis of stratigraphic position: the Hilda Lake Member is the lowermost member of the Grand Centre Formation; the Vilna Member is the uppermost. As well, the two are separated by the Reita Lake and Kehiwin Lake Members.

The differentiation between the Vilna Member and the Kehiwin Lake Member is discussed in the previous section.

The Vilna Member is differentiated from the Marie Creek Formation on the basis of stratigraphic position and carbonate content of the very coarse sand fraction. The Vilna Member overlies the Marie Creek Formation and in places the two are separated by stratified deposits of the Sand River Formation. The upper part of the Marie Creek Formation also contains more calcareous material compared to the Vilna Member (Table 2).

The differentiation between the two units is more difficult in the west-central part of the map area, where the distinctive high carbonate part of the Marie Creek Formation has been eroded and incorporated into the Vilna Member as discrete masses of glacially displaced material (Figure 9, x-sec N1-N1', testhole 77SR-12, and testholes 77SR-8, 77SR-20 and 77SR-22, Appendix A). In these places carbonate content of the two units may be very similar.

The Vilna Member directly overlies the Bonnyville Formation in only a few places in the west part of the map area (Figure 9, x-sec E4-E4'). The two units are difficult to differentiate because locally their texture and very coarse sand composition are similar (Appendix A, testhole 77SR-21). The two are more easily differentiated in the northwest where the Bonnyville Formation is typically more sandy, and is oxidized olive-brown color, in contrast to the more clayey, unoxidized base of the Vilna Member (Appendix A, testholes 77SR-27 and 77SR-28). As well, in the northwest the two units are commonly separated by stratified sediment of the Sand River Formation.

Nature of Contacts

Lower Contact

The contact between the Vilna and Kehiwin Lake Members is discussed in the previous section.

The contact of the Vilna Member with the top of the Sand River Formation is almost everywhere sharp and easily recognized. Where the Sand River Formation is absent and where the Vilna Member directly overlies the Marie Creek Formation, the contact may be difficult to establish because in the west part of the map area the two units have a similar texture and electric log response. Furthermore, the incorporation of intact, glacially displaced masses of the the underlying Marie Creek Formation within the Vilna Member, makes the undisturbed contact difficult to recognize.

The contact between the Vilna Member and the Bonnyville Formation is established primarily on the basis of color; the top of the Bonnyville Formation is more oxidized and lighter colored than the base of the the Vilna Member. The contact with both the Marie Creek and Bonnyville Formations is considered to be disconformable.

Upper Contact

The surface of the Vilna Member is presently exposed except for those areas where it is buried by postglacial stratified sediment (Fenton and Andriashek, 1983).

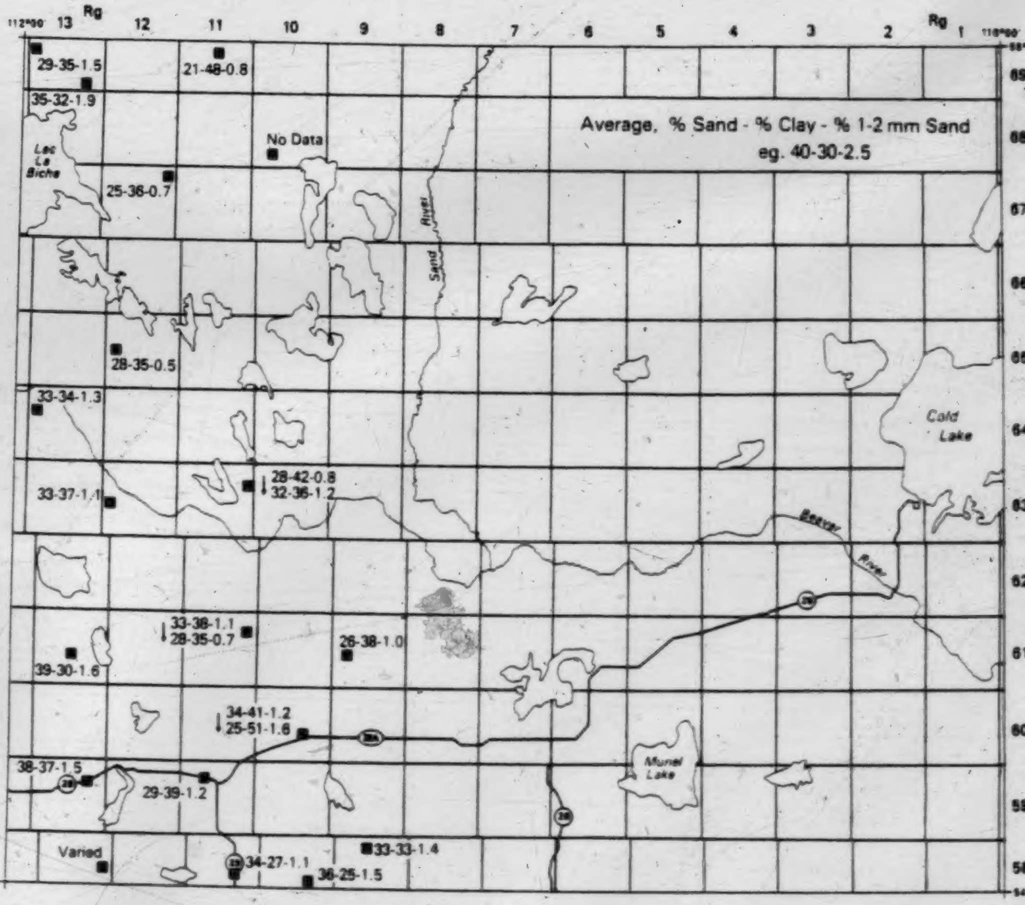
Origin and variations in the till properties

The Vilna Member represents glacial sediment which was deposited by the Lac LaBiche Lobe during the latter stages of the Cold Lake Glaciation. The Lac LaBiche lobe advanced from the northwest and is considered to represent a remobilization of the retreating margin of the Seibert Lobe. The southeast orientation of glacially streamlined features on the surface of the Vilna Member indicate that the lateral extent of the lobe was likely restricted by local factors, possibly by the the underlying topography and by the glacier mass of the Seibert Lobe to the northeast. It is believed that the southwest rise in the underlying topography likely prevented the fast-flowing component of the ice-stream from extending into the extreme southwest corner of the map area (Figures 4, 26, and 54). Although the Lac LaBiche Lobe did extend into the far southwest corner, it was in the form of a thin, slow-moving ice-sheet. The evidence for this consists of low relief, stagnant-ice landforms on the surface of the Vilna Member, as well as the relatively thin cover of the Vilna till, both of which suggest the glacier was thin and relatively debris-free in that area. As well, the contact between the Vilna and Kehiwin Lake tills is sharp and very well defined here, indicating that very little erosion of the Kehiwin Lake till occurred.

The northeast margin of the Lac LaBiche Lobe was likely bounded by the margin of the Seibert Lobe. Evidence for this is the interfingering to gradational contact between the Vilna and Kehiwin Lake Members in the west-central part of the map area and, the hummocky, interlobate moraine which forms the western part of the Seibert Lake Upland (Figure 9, x-sec N2-N2', and Fenton and Andriashek, 1983). Both lines of evidence indicate confluent flow of the two ice-lobes. Confluent flow is also indicated by the deflection southward, of the flutes on the surface of the Vilna Member, as the southeastern flowing Lac LaBiche Lobe merged with the southward-flowing Seibert Lobe (Figure 43).

The Lac LaBiche Lobe was erosive along the northeast facing flank in the regional topography in the Garner Lake and Lac LaBiche Uplands. This erosion occurred in the form of extensive glacial ice-thrusting which displaced large, intact blocks of the underlying units (Fenton and Andriashek, 1983). This accounts for the predominance of glacially displaced shale, siltstone and older Pleistocene sediments within the Vilna Member in the southwest. In fact it is believed that the absence of the Kehiwin Lake Member in most of the western and northwestern part of the map area can be attributed to this erosion.

The wide range of lithologic properties, as well as the clayey texture of the Vilna Member (Figure 60), is primarily due to the incorporation of shale and siltstone by the Lac LaBiche Lobe (Plate 6). The result of this incorporation is that it is difficult to characterize the Vilna Member from outcrop to outcrop. This is especially true in the Garner Lake Upland where much of the member is composed of glacially displaced shale and siltstone (Plate 6b). In Tp 59, Rg 9, along the southeast part of the Garner Lake Upland, these slabs of displaced shale and siltstone have been reworked to form a very clayey till composed almost entirely of well rounded "clasts" of clay. The properties of the Vilna Member are also variable within the Lac LaBiche and Seibert Lake Uplands. Although displaced shale is less abundant within the member here, slabs of glacially displaced till of the Marie Creek Formation are relatively common. North of Lac LaBiche, River in Tps 67-69, much of the Vilna Member consists of glacially displaced stratified sediment (Plate 6a). Near Owl River, for example, the member consists almost entirely of glacially overriden and deformed outwash sand (Fenton and Andriashek, 1983). As well, the data suggests that the underlying Bonnyville Formation has also been eroded and incorporated into the Vilna till. This is shown by the similarity of the calcite to dolomite ratios for both till units (.33 for the Vilna Member, compared to .37 for the Bonnyville Formation). In contrast, the Vilna Member within the Vilna Plain in the southwest corner of the map area, consists mainly of till that has relatively uniform textural and lithic composition. In this area the member does not contain masses of glacially displaced sediment, but rather, appears to have been deposited as a thin drape of meltout till on top of the Kehiwin Lake Member. The evidence for this is that the morphology of the till consists of shallow, dimpled hummocks or "doughnuts", which are indicative of deposition in a meltout, collapse environment (Fenton and Andriashek, 1983).


112°00'
13
Rg
12
11
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8
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3
2
Rg
1
110°00'
55°00'
69
Tp
68
67
66
65
64
63
62
61
60
59
Tp
58
54°00'
Average, % Sand - % Clay - % 1-2 mm Sand
eg. 40-30-2.5
29-35-1.5
21-48-0.8
35-32-1.9
Lac La Biche
No Data
25-36-0.7
Sand River
28-35-0.5
33-34-1.3
Cold Lake
33-37-1.1
28-42-0.8
32-36-1.2
Beaver River
33-38-1.1
28-35-0.7
26-38-1.0
39-30-1.6
34-41-1.2
25-51-1.6
38-37-1.5
29-39-1.2
Muriel Lake
Varied
34-27-1.1
33-33-1.4
36-25-1.5

Figure: 60 Regional variations in the textural properties of the Vilna Member.

XII. DISCUSSION OF ALTERNATIVE INTERPRETATIONS

The focus of this study has been to characterize the lithologic properties of the Quaternary units in the Sand River area for the purpose of defining and correlating stratigraphic horizons throughout the area. This has been accomplished using a variety of methods including outcrop and testhole observations, analytical data, and geophysical techniques. From these descriptive and analytical procedures, genetic interpretations have been made for each of the units, and from these, a history of the units is proposed.

Throughout this study, an attempt has been made conceptually to treat the lithologic units in a descriptive manner and to not apply genetic interpretions until all data were available. Thus, for purposes of characterization and correlation, glacial units are referred to as "diamictions" until the data supports a glacial genesis, that is, till. This may seem unnecessarily awkward, and generally most researchers would not avoid applying genetic interpretations to initial field observations. In fact, working from outcrops of tills, Shaw (1982, pg 1549) states "...the problem is not to identify till in itself, but to determine the process by which it was formed." Unfortunately, in working with subsurface data the genesis of a diamicton is not readily apparent. Thus, the initial problems do focus on differentiating glacial diamictons (tills) from diamctons of other origins. The problem stems in part from the fact that in a borehole units are mapped from small handsamples. These hand samples are disturbed by the drilling process and commonly are contaminated with up-hole material. This makes it difficult to determine not only the genesis of the unit, but the lithologic composition as well. As an example to illustrate this, a hand sample of massive clay, containing a few imbedded stones, can be interpreted in numerous ways: an extremely clay-rich till with few clasts, a massive lacustrine deposit with a few drop stones, a bed of displaced shale with glacially injected stones, or, a clay bed of undifferentiated fluvial, lacustrine or bedrock origin, slumped from the valley walls. A glacial event can be inferred in the first three of the above examples however, even though the glacier may not necessarily have deposited the material directly. Thus, even without knowing the exact process of deposition, some statements can be made about the general history of the area.

A sedimentological classification of the tills (for example, lodgment, melt-out, or, resedimented supraglacial debris or flow-till) was not feasible in this study for a number of reasons. Firstly, such a classification would require numerous and detailed outcrop observations of pebble fabrics, structures, nature of contacts, and stratified intrabeds within the diamictons. Few outcrops were found in this study area, and those that were, revealed only the upper part of the stratigraphic sequence. Secondly, the scope of coverage in the investigation and the time available did not permit detailed mapping of the few outcrops in the area.

In this study the genetic interpretations of the till and intertill stratified units suggest that four major glaciations occurred in the area, each depositing a uniquely different till. This hypothesis forms the foundation for the proposed Quaternary history, presented in the following chapter. Before considering that history, a discussion of alternative interpretations, that is, other than each till having been deposited by a separate glacier advance, is warranted. In other words, are there other processes which can produce a multiple lithostratigraphic sequence, besides multiple glaciations?

Lawson (1979) and DiLabio (1981) specifically address this point. They recognize that multiple till and intertill sequences, historically interpreted to have been deposited by separate glacial advances, may consist of tills with properties that reflect differences in provenance source, mode of transport, and depositional process, but which were deposited by a single glacial advance. DiLabio (1981) emphasizes that three fundamental processes in the genesis of a glacial unit must addressed before its historical significance can be appreciated. The first process considers the mechanism by which the debris is entrained and transported within the glacier. The second process considers the provenance source and dynamics of glacier flow as it affects the incorporation and transport of debris within the glacier. The third process considers the depositional environment of the debris in the glacier, and its influence of the character of the till. The remainder of this discussion addresses each of these concerns and their possible influence on the interpretation of the stratigraphic sequence in the Sand River area.

Debris entrainment and transport within ice

Recent studies have attempted to document the nature of erosion and entrainment of debris in modern glaciers. Lawson (1979) provides a detailed sedimentological study of the nature of transport of debris in the Matanuska Glacier in Alaska, as well as the nature of deposition of that debris. Lawson demonstrates that most of the debris in the glacier is concentrated at the base of the glacier, and that it is segregated into texturally distinct facies within the ice, and not as the heterogeneous distribution which characterizes classic "till". A restricted grain size distribution within each of these facies is attributed to both the combinational effects of an intially size-segregated source, and the effects of entrainment. In the lowermost facies which contains the greatest concentration of material, the variations in grain size are attributed to the source of the sediment, rather than the process of entrainment. Given this segregation of debris into texturally discrete bands within the glacier, Lawson states that one would expect that if the interstitial ice melts by simple removal, in a basal melt-out environment for example, a stratified sedimentary sequence would result, rather than homogeneous till. The fact that the texture of a given till in Lawson's study is essentially the same throughout, and that segregation into distinct particle sizes is rare, indicated to Lawson that it is the process of deposition, rather than entrainment and transport which produces the homogeneity of a till.

Given the general homogeneous nature of till, what can be said about the process which produces stratified intrabeds commonly seen in tills, both within this study and in the Edmonton area (Shaw, 1982)? Lawson states that if the till was deposited by basal melt-out, the preservation and recognition of debris stratification within a till sequence is generally poor, because mixing, as the sediment moves downward in the voids produced by the melting ice, generally destroys such structures. The preservation of these structures would occurr only if the amount of interstitial ice is small, whereby grain to grain contact is high and little adjustment occurs, or, if the particle-size segregation is so uniform and distinct that a discrete lense or layer will be recognized even with some disturbance due to the removal of interstitial ice. Thus, whereas debris is texturally segregated into distinct bands by the process of entrainment and transport, this segregation is very poorly or not preserved during deposition by the basal melt-out process. From Lawson's conclusions, it seems more likely that stratified intrabeds are produced by the resedimentation process, in which fluvial sorting at surface of the glacier deposits lenses or beds of stratified material, and which are later buried by flow deposits of diamicton. Thus, any particle segregation which occurrs within the ice, is expressed in the till only by gross textural differences. Any particle-sorted bed found within a diamicton therefore likely reflects the depositional process, rather than the entrainment and transport process.

DiLabio's (1981) study of the properties of tills in dispersal trains of a glacially eroded, mineralized bedrock source in the Icon mine area of Quebec, highlights the importance of understanding the nature of entrainment and deposition of units in a lithostratigraphic sequence, prior to assigning historical significance to that sequence. DiLabio's observations suggest that a compositional and structural segregation of debris can occur within a single glacier so as to produce more than one lithologically distinct till. Dilabio recognizes that a "till couplet" can be formed by one glaciation: an upper till which contains material derived from great distance, and a lower till containing locally derived material. He contends that the more distant travelled material is transported higher up in the glacier and therefore is transported farther. If this englacial "erratic" debris is deposited in an ablation environment from a stagnant glacier, the resulting till would be expected to contain more erratic material, compared to the basal till. DiLabio cites previous work which shows this to be the case. As well, the removal of the fine particles from the melting ice, by fluvial sorting, in an ablation environment would likely produce an upper till that was sandier than a basal lodgment till. Thus, two lithologicaly different tills can be produced by the combination of different bedrock sources, mode of transport and process of deposition.

Shetsen's (1884) work in southern Alberta demonstrates how the vertical and lateral composition of a regional till can vary due to the irregular entrainment of underlying material. In her study area Shetsen demonstrates that the pebble composition of a till can be so modified by the local incorporation of underlying gravel, that it bears little or no resemblance to the regional composition of that till. She cautions future workers in using percentages of rock types to characterize and correlate tills, and suggests that statistical techniques be employed which suppress the effects of local entrainment and emphasize the regional trends. To illustrate this, Shetsen demonstrates how the incorporation of a gravel deposit, containing "erratic" clasts, produces a well defined dispersal fan of erratic clasts, which extends for tens of kilometres within the regional till (Shetsen 1984, pg 928).

How can the studies and conclusions of these workers on the nature of debris entrainment and transport be applied to interpret the lithostratigraphic sequence presented in this study? Do their conclusions support or refute the hypothesis that all the tills in the sequence represent deposits of one, or possibly two glaciers? If this hypothesis were true, then one might expect to find a till "couplet", that is, a lodgment or melt-out till at the base of the stratigraphic sequence, which reflects the texture and petrologic composition of the local bedrock, and an ablation or resedimented, upper sandy till, containing more erratic material, at the top of the sequence. Certainly, the lowermost till, the Bronson Lake till, is the most clayey and appears to contain the most amount of local bedrock. As well, the tills do become sandier, with more erratic material, towards the top of the sequence. However, the following argue against applying the till "couplet" model for the entire till sequence, but do support a multiple glaciation model. Firstly, thick (>10m) widespread deposits of stratified sediment lie between each of the four tills, suggesting significant breaks in the deposition of the tills. These breaks likely represent prolonged nonglacial periods, as evidenced by the weathered profiles on the surfaces of the upper three tills. Thirdly, the composition, both texturally and petrologically, of the base of each till commonly shows enrichment of material derived from underlying units, whereas the tops of each till show little or no enrichment. This suggests that a till "couplet" can be recgonized for each of the four tills, and this implies that each till represents a separate depositional event. Such vertical variations in the till composition, reflecting differences in the amount of entrainment of underlying gravel, were similarily recognized in the clast composition of tills in southern Alberta (Shetsen 1984).

Further addressing the last point above, tills in the Sand River support the general observations of DiLabio (1981) in that they commonly, though not always, exhibit a couplet composed of a clayey base and a sandier top (Table 2 and Figures 15, 46). Incorporation of bedrock shale accounts, in part, for the clayey bases of the Bronson Lake, Bonnyville and Grand Centre Formations, whereas incorporation of lacustrine silt and clay accounts for the clayey base of the Marie Creek till. Variations in the overall composition of each till can be attributed to fluctuations caused by irregular entrainment of the underlying units (Shetsen 1984). The origin of the sandier part of each till couplet is less certain. The facies could represent debris from a source area common to all tills at some distance far up-glacier, or, the facies could represent a resedimented or ablation facies. The premise that the upper member of the couplet reflects more distant travelled material is clearly supported in one case, by the high dolostone facies of the Marie Creek till (Table 2). This high dolostone facies is consdered to represent the entrainment and transport high up in the glacier profile, of carbonate rocks from northeast Alberta. A very sandy ablation facies accounts for the upper sandy till of the Grand Centre Formation in the northeast part of the map area, as evidenced by well developed stagnant-ice landforms.

Nature of debris within ice-streams of large glaciers

Recent work in the central Canadian Arctic (Dyke 1984) demonstrates how the composition of a till can vary regionally as a function of ice lobes or streams within large ice masses. Dyke (1984) shows that given a similar or uniform source area for debris, debris segregations or concentrations can occurr in the ice (and therefore in the resulting till) due to the increased erosiveness of faster flowing ice streams at the base of the glacier. Dyke (1984) mapped two regional high carbonate dispersal trains, one about 150 km wide and the other about 220 km wide, separated by a very low carbonate inter-dispersal zone. Within each dispersal a high carbonate content was expressed in both the matrix and fine gravel fractions of the till. The fact that the bedrock source is the same for both dispersals, that the dispersal have sharply defined edges, and that glacially streamlined bedforms are larger and better expressed within these dispersal trains, indicate to Dyke that the erosion and enrichment of carbonates is as a result of the convergence of ice-flow within two discrete streams.

This study demonstrates that such convergence of glacial flow within discrete ice-streams likely accounts for the compositional difference of the Vilna Member of the Grand Centre Formation. A narrow, well defined ice-stream, the Lac LaBiche Lobe (Figure 43) is expressed not only in the textural composition of the Vilna till, but also by the numerous large scale glacial ice-thrust and streamlined features (Fenton and Andriashek 1983). Many of these features are composed of glacially displaced bedrock, which supports Dyke's (1984) conclusion that the streams have greater erosive capability.

What subsurface evidence exists to indicate that that the lateral variations in the buried tills in this study are due to discrete ice-streams within the glacier? To answer this, some assumptions must be made. Firstly, any ice-stream in the study area must necessarily be narrower than the map boundary, otherwise, the properties of the till within the dispersal would be the same, or show little change in the study area. Secondly, a homogeneous lithologic source for the till is essential, otherwise variations in the till composition could be explained by a uniform amount of erosion of different rock types, rather than differential erosion within an ice-stream. Thirdly, it is critical that the entire vertical sequence of the till is preserved within the subsurface, and that the mapping of the dispersal is conducted on the same horizon. As discussed previously, variations in the vertical profile of an individual till, as a result of local incorporation, can produce a markedly different composition of the base compared to the top. Thus, one must be certain that noneroded tops of the same till are being mapped. Given these conditions, is there evidence that there are dispersal trains in the buried tills which can be related to ice-streams? The only evidence of this is the distribution of the high dolostone facies of the Marie Creek till which suggests deposition from an ice-stream flowing from slightly west of north. The absence of the high carbonate Marie Creek till in the southwest corner of the map area is interpreted to represent erosion of the till following its deposition. However, another interpretation is that the Marie Creek till represents a high carbonate dispersal which was deposited from an ice-stream flowing from the northwest, and which did not enter into the southwest corner of the map area. Certainly, the north to slightly west of north orientiations of pebbles in the Marie Creek till at one outcrop in the east support glacial flow from northwest. Perhaps the thick deposits of the Marie Creek till and stratified deposits of the underlying Ethel Lake Formation in the southwest represent deposition along the southwest boundary of an ice-stream from the northwest (Figures 31 and 36). Coincidentally, if the direction of flow for the ice-stream which deposited the Marie Creek till was from the northwest, it is the same direction of flow as the ice-stream which deposited the overlying Vilna Member of the Grand Centre Formation.

Nature of till deposition

Deposition is the final process which can influence the composition of a till. The interaction of a number of factors, some of which include the mode of deposition (lodgment, basal melt-out, supraglacial melt-out, or resedimentation), temperature, presence of free water, drainage, and relief, can all impact the deposition process as debris is released from the glacier. As DiLabio (1981) and Lawson (1979) indicate, the character of the sediment deposited by a single glaciation can have markedly different properties with depth, depending on the process of deposition. Till deposited by the lodgment of debris at the base of moving glacier, may contain more locally derived material and have a finer matrix due to greater comminution at the glacier bed. On the other hand, till deposited by the release of debris from higher up in an ablating glacier, may be coarser, due to sorting by flowing water, and may contain more far-travelled material. Hence, vertical variations in the till sequence may result not only from the segregation of compositionally different debris during the entrainment process, but also by the nature of deposition.

With respect to the process of deposition, a number of questions arise in the interpretation of the lithostratigraphy of this study. Firstly, is there evidence to indicate the depositional environment of each of the tills? In other words, can one recognize lodgment, melt-out, or ablation tills in the subsurface? Secondly, what is the sedimentological significance of the stratified sediment which lies both as large units between the tills, and as intrabeds within the diamictons?

There is insufficient lithologic data for the Bronson Lake Formations to address either of these questions. On the basis of textural differences, one might suggest that the discontinuous clayey till at the base of the Bonnyville Formation (unit 1), and the extensive, upper sandy till (unit 2), represents a till "couplet", that is, a finer textured basal lodgment or melt-out till, and a coarser ablation till. The thick, intertill sequence of sand and gravel between the two units in some places suggests however, that the two tills were deposited by separate glacial advances, and therefore do not represent a couplet.

The data for the Marie Creek Formation on the other hand, supports a melt-out till hypothesis. Firstly, the presence of silt and clay "clasts" at the base of the till (unit 1) excludes the lodgment process because such soft clasts would not survive the comminution and lodging process. Similarily, the presence of discrete intrabeds of stratified sand within the till in some locations (Plate 4) also exclude lodgment, as these lenses could not survive the lodgment process either (Shaw 1982). These stratified intrabeds do suggest however, either a supraglacial ablation, or basal melt-out origin for the Marie Creek till. Assuming a supraglacial ablation origin, then the sand lenses can be interpreted to be fluvial sediment deposited on the glacier surface. These lenses were subsequently buried by slumped diamicton or "flow-till" (Gravenor 1955, Hartshorn 1958, Boulton 1968, Lawson 1979), as the surface of the ice underwent repeated topographic inversions during melt. An ablation till hypothesis is also supported by the presence, in places, of irregularly shaped and inclined lenses of sand (Plate 4B) which suggests that the lenses were folded and distorted as a result of slumping due to the melting of buried ice. A melt-out till hypothesis however can also explain the presence of these stratified intrabeds. The presence of nearly horizontal sand lenses with undisturbed bedding suggests they were deposited synchronously with the diamicton (Plate 4A). Shaw (1982) proposes that such lenses can be deposited by water flowing at the base of a slow melting, stagnant glacier. This water is channeled under the melting glacier but as new drainage outlets develop, the channels are abandoned. This accounts for the discontinuous distribution of the sand lenses. Further downmelting releases the entrained debris within the ice, resulting in a drape of diamicton overtop the sand lenses. As the glacier continues to melt, the process repeats, such that a vertical sequence of diamicton and sporadically distributed intrabeds of sand is produced. Because this melt-out process is slow, the let-down of entrained debris is gentle, and this preserves the inherent fabric of the pebbles in the glacier (Lawson 1979). Hence, a strong pebble fabric in the tills of the Edmonton area, indicated to Shaw (1982) that the diamicton and sand intrabed sequence which he examined was deposited by basal melt-out rather than by resedimentation of supraglacial debris. Similarly, in this study a strong pebble fabric in the Marie Creek till (Figure 38) as well as the sand intrabeds in the diamicton, support a basal melt-out, rather supraglacial ablation origin.

The depositional origins of the four members of the Grand Centre Formation are uncertain. Well developed glacially streamlined features on the surface of all four members suggests that they were deposited by active ice, and may therefore have a strong lodgment component. Stagnant ice landforms which, in some areas, drape the streamlined landforms (Fenton and Andriashek 1983) indicate an ablation component to the tills, which suggests that a till "couplet" may be present. In the east part of the map area the till "couplet" model can explain the origin of a sandy-clay upper till (Reita Lake till) and a denser, more clayey lower till (Hilda Lake till) (Table 2 and Figure 46). The lower till contains masses of ice-thrust shale, it is denser, contains more clay and had been glacially streamlined. Clearly, the much of the material in the till was derived from local bedrock. These properties suggest that the Hilda Lake till was deposited as either a lodgment till, or basal melt-out till (Lawson 1979, DiLabio 1981). Glacially displaced beds of older stratified sediment within the diamicton suggest that a basal melt-out origin is more likely (Shaw 1982). Much of the upper till (Reita Lake till) is interpreted to have a supraglacial ablation origin. It is less clayey and more sandy, and in the subsurface, beds of sand (1-2 m thick) are found locally within the diamicton, or at the contact with the lower clayey till. These beds are composed of glaciofluvial sediment, which may have been deposited penecontemporaneously with the diamciton (Shaw 1982), though sedimentological evidence for this is lacking. Commonly, the upper till forms stagnant-ice, collapse features ("doughnuts", hummocks, and circular rimmed ridges, Fenton and Andriashek 1983)) and in the northeast the till within these collapse landforms is much sandier, resembling poorly sorted glaciofluvial outwash. All of these properties support a supraglacial melt-out interpretation. In the central and east part of the map area however, the upper till has been glacially streamlined (Fenton and Andriashek 1983) and here the till may have been deposited by basal melt-out. The sedimentological origin of the Kehiwin Lake till is even less certain. Well developed, glacially streamlined landforms, draped by supraglacial, crevasse-filled sediment suggest a till "couplet", similar to the above sequence. However, textural distinct upper and lower units were not recognized the member. Similarities in both texture, glacially displaced bedrock, and glacially streamlined landforms between the Vilna and Hilda Lake Members suggest that the Vilna Member had a basal melt-out origin as well.

Summary

The subsurface and analytical data provide some evidence that sedimentological facies, reflecting the nature of debris entrainment, transport and deposition, can be recognized within the upper tills in the stratigraphic sequence in the Sand River area. Compositional differences between the tills, thick and extensive stratified inter-till deposits, and weathered horizons on the surfaces of each of the tills all suggest however that each till was deposited by a major glaciation, and that the multi-till sequence in the Sand River area cannot be explained by only one, or possibly even two, glaciations.

Table 12 summarizes the tentative correlations of the lithostratigraphic units in this study with those defined by previous workers in the region, primarily Gold's (1978) work in east-central Alberta, and Christiansen's (1968) work in Saskatchewan. Included within the table are the main criteria used in making the correlations. The correlations carry varying degress of certainty, depending on the units involved. For example, the correlations of the upper till sequence in this study are generally good with the sequence proposed by Gold (1978). Conversely, the correlations of these units with those in Saskatchewan (Christiansen 1968) are much more suspect.

Very tentatively, ages have been assigned to the stratigraphic sequence (Table 12), even though datable material was not found within any of the units. Weathered profiles on the surfaces of the buried tills establish that prolonged periods of time followed the deposition of the tills. The ages of only two stratigraphic units can be stated with any degree of confidence. The oldest unit, unit 1 of the Empress Formation, is preglacial and likely is of Tertiary age. The youngest unit, the Grand Centre Formation, is assumed to have been deposited by the last glacier, and probably is of late Wisconsin age.

Table 12: Proposed regional correlations and ages of lithostratigraphic units

Stratigraphic units in east-central Alberta		Stratigraphic units in this study	Possible Age	Stratigraphic units in Saskatchewan	
Name	**Correlation criteria**	**Name**		**Name**	**Correlation Criteria**
Till unit 1 (Gold 1978)	• uppermost till • lower matrix carbonate than underlying till • less oxidized than top of underlying till	**Grand Centre Formation**	Late Wisconsin	Battleford Formation (Christiansen 1968)	• uppermost till • soft, unconsolidated, massive to fissile • less oxidized than underlying till • low matrix carbonate • basal boulder concentration
		Sand River Formation	Mid-Wisconsin?		
Till unit 2 (Gold 1978)	• high carbonate content in matrix and coarse sand • strongly oxidized surface • higher resistivity than above till • second till in sequence	**Marie Creek Formation**	Early Wisconsin?	Floral Formation (Christiansen 1968)	• fractured, jointed, highly oxidized surface • consolidated, difficult to drill • higher matrix carbonate content • second till in sequence
		Ethel Lake Formation	Early Wisconsin?		
Till unit 3 (Gold 1978)	• low carbonate content in matrix and • coarse sand • slightly higher quartz content in coarse sand • third till in sequence	**Bonnyville Formation** Unit 2	Pre-Wisconsin?	Sutherland Group (Christiansen 1968) Upper till	• low dolomite content in matrix • oxidized surface • third till in sequence
Till unit 4 (Gold 1978)	• high clay content • low resistivity	Unit 1		Intertill deposits and lower till	• high clay content • low resistivity • confined to buried valleys
		Muriel Lake Formation	Pre-Wisconsin?		
Till unit 4 (Gold 1978)	• very low resistivity • high local bedrock content • high clay content • confined to buried valleys • lowermost till in sequence	**Bronson Lake Formation**	Pre-Wisconsin?	Sutherland Group Lower till	• high clay content • low matrix carbonate content • lowermost till in sequence • confined to buried valleys
		Empress Formation		Empress Group (Whitaker and Christiansen 1972)	• stratigraphic position • composition of clasts
		Unit 3	Early Quaternary		
		Unit 2	Early Quaternary to Late Tertiary		
Saskatchewan sand and gravel (Rutherford 1937, Stalker 1967)	• quartzite, chert and local bedrock clasts in gravel, 'salt and pepper' colored sand on floors of buried preglacial valleys	Unit 1	Tertiary		

XIII. STRATIGRAPHIC INTERPRETATION OF THE SAND RIVER MAP AREA

A. Preglacial History

Two major drainage systems, the Helina Valley and the Beverly Valley, developed on the bedrock surface prior to glaciation in the Sand River map area. Both systems had their headwaters in the Cordilleran region and drained northeast, depositing quartzite and chert gravel, derived from the Rocky Mountains, on the broad floors of their valleys. "Salt and pepper" colored quartz and chert sand, derived from the local bedrock, was eroded later, and deposited on top of the gravel. Previous workers (Rutherford, 1937, Stalker, 1967) called these basal fluvial deposits the "Saskatchewan sand and gravel" and these constitute unit 1 of the Empress Formation.

These two drainage systems developed over a long period in the Tertiary. It is likely that stream capture of the drainage in these valleys occurred. This is certainly indicated within segments of the Helina Valley, where flow was in opposite directions for some period during its history.

The development of tributaries on the Beverly and Helina drainage systems, formed the Vegreville, Vermilion, Sinclair, Imperial Mills and possibly St. Paul Valleys. These tributaries had their headwaters in the plains region of Alberta, and eroded the unconsolidated Cretaceous shale and sandstone rocks. Most of this eroded material was redeposited as sand, with little or no gravel, at the base of these tributary valleys.

B. Quaternary History

The glacial and non-glacial deposits of the Quaternary sequence record the advance and retreat phases of four major glaciations in the Sand River map area. From oldest to youngest, these are the: Cherry Grove, Fort Kent, Ardmore, and Cold Lake Glaciations (Table 11).

Event One: Cherry Grove Glaciation

Advance Phase

The three units of the Empress Formation reflect the transition from sedimentation within a Tertiary drainage system to deposition in a drainage a system influenced by the advance of the Cherry Grove Glacier into the Sand River area. These major drainage systems began to adjust to the blockage by ice in the valleys even while the Cherry Grove Glacier was at some distance northeast of the the study area. Presumably, at this time drainage to the north, within the Wiau Valley, was diverted south, eroding the Imperial Mills Valley, and emptying into the Helina Valley. Preglacial sand and gravel of unit 1 of the Empress Formation were eroded from within the Wiau Valley, and redeposited on the floor of the Imperial Mills Valley by this diverted water.

As the Cherry Grove Glacier continued to advance south, the drainage in the Helina Valley was blocked and the water was diverted southeast toward the Beverly Valley, this time eroding the the Kikino Valley. Similarly, preglacial deposits were eroded from within the Helina Valley and deposited on the floor of the Kikino Valley.

The blockage by ice produced a series of ice-ponded lakes which effectively decreased the gradients of the preglacial rivers, and caused the fine suspended sediment of unit 2 of the Empress Formation to be deposited overtop the coarser basal sand and gravel.

A complex sequence of both glacial and glaciofluvial erosion and deposition occurred following the deposition of unit 2 silt and clay. After the Cherry Grove Glacier advanced into the Helina Valley, drainage within the Beverly Valley was blocked and began to pond against the glacier ice. The water level rose until it flowed overtop top the confining walls of the Beverly Valley, and then drained northeast, probably along the glacier margin. This likely occurred in the form of a spillway which eroded the Moore Lake Valley. Possibly the eastern end of the Helina Valley in the study area was not completely blocked by ice, and this enabled the diverted water to continue draining northeast into Saskatchewan.

At the same time, glacial meltwater was also flowing directly from the Cherry Grove Glacier margin. In places along the western end of the Moore Lake Valley sand and gravel was deposited in contact with the ice, so as to ultimatley lie at elevations higher than the surrounding unit 3 deposits. In other places, the meltwater had sufficient force to scour and over-deepen the west end of the Moore Lake Valley. Elsewhere, glaciofluvial sand and gravel was deposited overtop unit 2 clay within the Beverly valley. Glacial sediment of the Bronson Lake Formation was then deposited overtop of all units of the Empress Formation, as the glacier continued southwest.

The Cherry Grove Glacier advanced southward to about Tp 63, where it halted again, forming an ice-marginal position defined by the Big Meadow Valley. Similarly, water within the Beverly Valley was diverted east, this time eroding the Big Meadow Valley. Sand and gravel of unit 1 of the Empress Formation were eroded from the Beverly Valley, and redeposited along the western segment of the Big Meadow Valley. Farther east, glaciofluvial sediment was deposited in the valley by meltwater flowing off the ice-margin, forming unit 3 of the Empress Formation. Likely, this diverted water drained into the Vermilion Valley and perhaps ultimately into the Hatfield system in Saskatchewan. Although the Bronson Lake Formation likely was deposited in this valley as well, its absence suggests that it was eroded by meltwater during the retreat phase of the Cherry Grove Glacier. Presumably, the northern branch of the Big Meadow Valley was eroded as well, during this retreat phase

The Cherry Grove Glacier margin was stable along the Big Meadow Valley for some period, though, an ice-lobe continued advancing southward, pivoting or hinging at the junction point of the Big Meadow Valley with the Beverly Valley in Tp 62, Rg 5: This lobe halted after only a short distance, forming another ice-margin. Drainage in the Beverly Valley was again ponded, and diverted southeast along the glacier margin, this time eroding the Bronson Lake Valley. As before, preglacial gravel on the floor of the Beverly Valley was eroded and redeposited within the western segment of the newly eroded Bronson Lake Valley. Farther east, glaciofluvial sand and gravel were deposited on the valley floor.

The extension of the Bronson Lake Valley across the preglacial Vermilion Valley and into Saskatchewan, indicates that by this time drainage in preglacial Vermilion Valley was also blocked by the glacier.

Till of the Bronson Lake Formation was deposited as the Cherry Grove Glacier passed over the Bronson Lake Valley. Later, this till was eroded in the eastern segment of the valley by meltwater during the retreat phase of the glacier.

The Holyoke Valley marks another halt in the southward advance of the Cherry Grove Glacier. It is uncertain if the valley was eroded by drainage diverted southeast from the Beverly Valley, or by glacial meltwater issuing from the glacier margin. The drainage within the Holyoke Valley is believed to have emptied into the preglacial Vermilion Valley beneath Frog Lake.

Another halt in the southward advance of the the Cherry Grove Glacier is marked by a thick kame deposit of sand and gravel which lies at a higher than normal elevation in the Beverly Valley in TP 59, Rgs 9-10. Meltwater, flowing from the ice-margin, deposited the kame and drained southwest, likely along the west branch of the St. Paul Valley.

The maximum extent of the Cherry Grove Glacier in the Sand River map area is uncertain, primarily because in the southwest corner it is difficult to differentiate glacial sediment of the Bronson Lake Formation from other glacial units. Gold (1978) believes that his lowermost till unit 4, which correlates with the Bronson Lake Formation, does not extend beyond the Kikino Valley and that in fact the Kikino Valley represents the terminal position of the first glacial advance in the area, presumably the Cherry Grove Glaciation. However, the substantial width of the valley suggests that it was formed over a much greater period than along an ice-marginal position. Thus, it is uncertain if the terminal position of the Cherry Grove Glacier is, in fact, marked by the Kikino Valley.

Retreat Phase

It is believed that a number of proglacial lakes also developed during the retreat of the Cherry Grove Glacier from the Sand River map area. This accounts for the thick basal clay of the Muriel Lake Formation, which overlies till of the Bronson Lake Formation in a number of places within the Helina valley (Figure 5, testholes E833, E831, E1720, E765).

The clay is thinner and is interbedded with sand and gravel in a number of places, (testholes E829, E802, E804, Figure 5) suggesting possibly a fluvial or glaciofluvial origin. Some of the coarser sand and gravel of the Muriel Lake Formation represents glaciofluvial sediment which was deposited during the retreat of the Cherry Grove Glacier. These coarse deposits mantled the Bronson Lake Formation within segments of the buried valleys, and on the upland south of the Bronson Lake Valley, and prevented the till from being eroded during the non-glacial period which followed.

During either the retreat of the Cherry Grove Glacier, or, perhaps during the advance of the following Fort Kent Glacier, ice-contact glaciofluvial sediment of the Muriel Lake Formation was deposited in the eastern portion of the Helina Valley, forming the core of the Medley River Upland physiographic unit.

Much of the Bronson Lake Formation was eroded during the non-glacial period which followed the retreat of the Cherry Grove Glacier. This accounts for the sporadic to discontinuous distribution of the formation in the uplands where it was exposed. In the area around Ethel Lake, the top of the formation was exposed and weathered sufficiently to oxidize the top of the till (Figure 29, testhole T-32).

Event Two: Fort Kent Glaciation

Advance Phase

A previously discussed, the advance of the Fort Kent Glacier possibly was preceeded by the deposition of glaciofluvial outwash of the Muriel Lake Formation, along the advancing ice-front. Till of the Bonnyville Formation was then deposited by the glacier throughout the entire study area. The Fort Kent Glacier most likely advanced from the northeast, rather than from the north or northwest. Though the evidence is uncertain, possibly two advances are associated with the glaciation. Extensive amounts of glacial ice-thrusting were associated with this advance, and large blocks of the underlying Lea Park and Belly River Formations were incorporated into the glacier. As a result, a very clayey till, containing discrete blocks of intact bedrock, was deposited by this advance, forming unit 1 of the Bonnyville Formation. Following this, during the retreat glaciofluvial outwash sand and gravel was deposited overtop of unit 1 in segments above the buried Helina and Beverly Valleys. The second advance extended throughout the entire map area. It deposited the sandier, high quartz till of unit 2 . Two ice margins of the Fort Kent Glacier are suggested by thick deposits of the Bonnyville Formation which form ridge-like uplands in the northeast and southwest parts of the map area.

Retreat Phase

Following the deposition of the Bonnyville Formation, the land surface was eroded by both meltwater from the retreating Fort Kent glacier and, the natural drainage. In the central part of the map area a parallel drainage system developed on the surface of the Bonnyville Formation (Figures 26 and 28). This system drained northeast along the Beaver River Lowland Plain and ultimately merged with the topographic low above the buried Helina Valley beneath Cold Lake. Much of the Bonnyville Formation was eroded along this system as shown by the relatively thin deposits of the formation within the system (Figure 28). Possibly, sand and gravel, which constitutes part of the Ethel Lake Formation in the central part of the map area, was deposited as this drainage system developed. There is no evidence that a major fluvial channel, such as similar to the present day North Saskatchewan River, developed after the Fort Kent Glacier retreated. This observation was also made by Gold (1978, pg 154) in his history of the Quaternary geology in his study area.

Elsewhere, the surface of the Bonnyville Formation was exposed and underwent weathering during the nonglacial period which followed. The lack of a well preserved oxidized horizon in the east possibly indicates that the formation either was not exposed for a lengthy period of time, or, that the surface of the formation was extensively oxidized, but eroded later. In the west, on the other hand the oxidized surface of the Bonnyville Formation is extensive and well developed. However, as will be discussed in more detail later, in the west the Bonnyville Formation was exposed to more than one weathering period, compared to the east.

Event Three: Ardmore Glaciation

Advance Phase

A series of ice-marginal, proglacial lakes preceeded the advance of the Ardmore Glaciation in the map area. These lakes formed as both meltwater flowed off the advancing ice margin and, as the regional northeast drainage was blocked by the southwest advancing glacier margin. These lakes migrated southward with the advancing glacier, and deposited extensive areas of silt and clay of the Ethel Lake Formation in the Beaver River Lowland Plain. As the glacier margin extended across the lowlands, these proglacial lakes migrated up against the north-facing regional slope of the Reita Lake Uplands. It is believed that the Ardmore Glacier halted against this slope in Tps 59-60, Rgs 1-6, long enough for a thick sequence of silt and clay to be deposited. This deposition occurred along the east-west ice-margin for a distance of about 45 km (Figure 31). As the Ardmore Glacier advanced up against this slope some of the underlying units in the Reita Lake Upland underwent compressive stress, subsequently failed and became incorporated into the glacier. In testhole T-5 (Figure 8, x-sec E1-E1') discrete mases of silt and clay of the Ethel Lake Formation, as well as the top of the underlying Bonnyville Formation were glacially thrust in response to this stress.

The Ardmore Glacial margin was likely very near to the proglacial lakes in the south-central part of the map area. This major ice-margin is defined by the curvilinear trend of the Ethel Lake Formation, which extends from Muriel Lake, west and northwest to Lac LaBiche (Figure 30). Initial interpretations placed a terminal postion of the Ardmore Glacier along this trend, mainly because till of that glaciation (the Marie Creek Formation) could not be recognized southwest of the trend. However, as is discussed shortly, this is probably not the case, and that the trend simply marks a halt during the advance.

Till of the Marie Creek Formation was deposited overtop the Ethel Lake Formation by the Ardmore Glacier. Within the Beaver River Lowlands Plain and, to a lesser degree the Reita Lake Uplands, much of the underlying unconsolidated silt and clay of the Ethel Lake Formation was eroded by the glacier. This formed a clayey basal till which comprises unit 1 of the Marie Creek Formation.

Pebble orientations in the matrix of the till, combined with the high carbonate content of the coarse sand and silt-clay fractions, indicate that in the east part of the map area the glacier advanced from slightly west of north, roughly parallel to the Devonian carbonate outcrop in northeast Alberta.

Although the Marie Creek till is not recognized in the southwest corner of the Sand River area, the presence of a high carbonate till in the Cooking Lake Moraine, east of

Edmonton, indicates that the Ardmore Glacier likely extended out of the map area. The absence of the Marie Creek till in the southwest of Sand River implies that it was eroded shortly after it was deposited.

After the advance and deposition of the Marie Creek Formation, the surface expression of the underlying bedrock topography was almost completely masked.

Retreat Phase

Glaciofluvial meltwater eroded the top of the Marie Creek Formation following the retreat of the Ardmore Glacier, forming a number of shallow, poorly defined valleys. Some of the stratified sediment of the Sand River Formation was deposited at the same time as the Ardmore Glacier retreated, either from glacial lakes, or from glaciofluvial meltwater. For the most part, erosion during the non-glacial period was relatively minor, and a widespread oxidized profile developed on the surface of the Marie Creek Formation. Leaching of the upper surface of the Marie Creek till was not significant.

Event 4: Cold Lake Glaciation

Advance Phase

Most of the sand of the Sand River Formation was deposited as either lacustrine sediment or glaciofluvial sediment during the advance of the Cold Lake Glacier. These deposits of sand were immediately buried by glacial sediment (till) of the Grand Centre Formation, and thus were not weathered and oxidized. Fluvial or lacustrine erosion resulted in the removal of the oxidized, high carbonate facies of the Marie Creek Formation in a few places.

Glacially streamlined landforms on the surface of the Grand Centre Formation, indicate that the Cold Lake Glacier advanced in the form of three distinct lobes; the Primrose Lobe from the northeast, which deposited the Reita lake and Hilda Lake Members, the Seibert Lobe from the north, which deposited the Kehiwin lake Member, and the Lac LaBiche Lobe from the northwest, which deposited the Vilna Member.

The first glacial lobe, the Primrose Lobe, advanced southwest at least as far as range 8, and perhaps even as far as the Tawatinaw and Vermilion map areas. Two advances of the Primrose Lobe may have occurred, though the evidence for this is not clear (see Chapter XII). The first of these advances possibly deposited the Hilda Lake Member, and the second deposited the Reita Lake Member.

Extensive glacial ice-thrusting was associated with the Primrose Lobe. This thrusting eroded the basins of the major lakes in the east part of the map area, including the Primrose, Cold, Wolf, Marie, Muriel and possibly Moose Lakes. In these areas the underlying till of the Marie Creek Formation was displaced by this thrusting and redeposited to form the high relief landforms which lie directly south of the major lakes.

At one stage of its advance, the Primrose Lobe formed an ice-margin in the central part of the map area. This margin extended essentially north-south, roughly parallel to the present day course of the Sand River in the north, and the Kehiwin Creek and Kehiwin Lake in the south. Confluent flow of the Primrose Lobe, flowing from the northeast, and the Seibert Lobe, flowing from the north, occurred along this margin. Minor oscillations in the position of this confluence resulted in intermixing of the two lobes, which produced an interfingering contact of the tills of the Reita Lake and Kehiwin Lake Members.

The southward flowing Seibert Lobe extended across the entire west half of the Sand River map area and into the Tawatinaw and Vermilion map areas. It deposited the sandy Kehiwin Lake till in the extreme southwest corner of the Sand River map and produced a series of glacial ice-thrust ridges south of Whitefish Lake and Saddle Lake. Extensive glacial ice-thrusting, associated with the advance of the Seibert Lobe, also produced the Seibert, Touchwood, and Spencer Lake basins in the north.

During the retreat phase of the Seibert Lobe glacial meltwater deposited sand and gravel within a poorly defined channel eroded onto the surface of the till in the far southwest corner of the map area. These stratified deposits were subsequently buried by till of the Lac LaBiche Lobe, which deposited till of the Vilna Member.

The Lac LaBiche Lobe is considered to represent a remobilization of the retreating margin of the Seibert Lobe. The lobe originated in the eastern edge of the Tawatinaw map area, and flowed southeast, essentially parallel to the margin of the Seibert Lobe. The Lac

LaBiche Lobe was not as extensive as the Seibert or Primrose Lobes, but rather, advanced in the form of a narrow, possibly relatively fast-flowing, ice-stream. Glacially streamlined features on the surface of the Vilna Member indicate that the Lac LaBiche Lobe extended southeast as far as the Lloydminster area (Fenton, in prep). The southeast orientation of these glacially streamlined features indicate that the lateral extent of the lobe was restricted by local factors such as the underlying rise in topography to the southwest and the neighboring ice-front of the Seibert Lobe to the northeast.

The Lac LaBiche Lobe was erosive along the northeast facing flank in the regional topography in the Garner Lake and Lac LaBiche Uplands. This erosion occurred in the form of extensive glacial ice-thrusting which displaced large intact blocks of the underlying stratigraphic units. It is believed that the much of the Kehiwin Lake Member in the western and northwestern parts of the map area was eroded at this time.

Retreat Phase

During the retreat of the Cold Lake Glacier, a meltwater channel, presently occupied by the Sand River in the north and the Kehiwin Lake in the south, drained southward along the contact of the Seibert and Primose Lobes. The channel was deeply incised, as much as 80 m below the present floodplain level of the Sand River, but was later infilled with glaciolacustrine clay, silt and sand. This infilling likely resulted from a blockage in the drainage by a readvance of the Primrose Lobe. In that segment of the valley between Tp 62, Rg 8 and Tp 60, Rg 8, the channel was completely infilled with ice-contact glaciofluvial sediment, forming a poorly defined esker-like ridge (Fenton and Andriashek, 1983).

A northeastward retreat of the Primrose Lobe allowed the meltwater in the central part of the map area to drain eastward. This eroded a new channel, extending east from the middle of Tp 62, Rg 8, to Tp 62, Rg 7, then south into Moose Lake and along the old channel in the west part of Tp 60, Rg 7 (Fenton and Andriashek, I983). The Primrose glacier margin continued to retreat northward but halted again, forming another margin along the north side of the Beaver River Lowland Plain (Fenton and Andriashek, 1983). At this time the meltwater abandoned the southward drainage system, drained eastward along the ice margin, eroding the initial channel of the present day Beaver River Valley. Glaciofluvial silt and sand was deposited overtop the Grand Centre Formation along the margins of this Beaver River meltwater system. Following this, the Lac LaBiche and Seibert Lobes retreated fully from the west part of the map area, and the western portion of the present day Beaver River system developed, ultimately merging with the meltwater channel in the east.

The final retreat of the Primrose Lobe in the northeast occurred in the form of a stagnant ice-mass which resulted in the depostion of the Grand Centre till within collapse, stagnant-ice landforms (Fenton and Andriashek, 1983).

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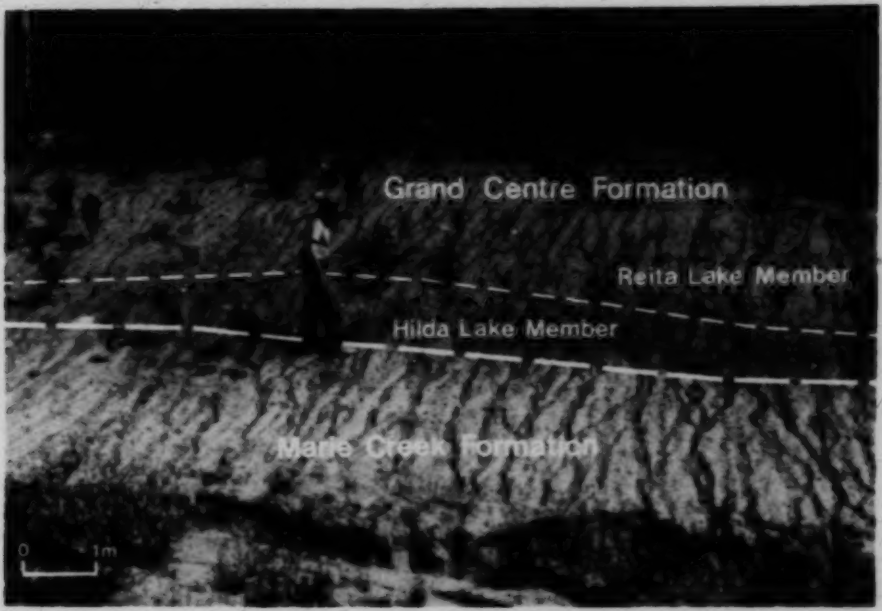
Plate 1


Grand Centre Formation
Reita Lake Member
Hilda Lake Member
Marie Creek Formation
0
1m

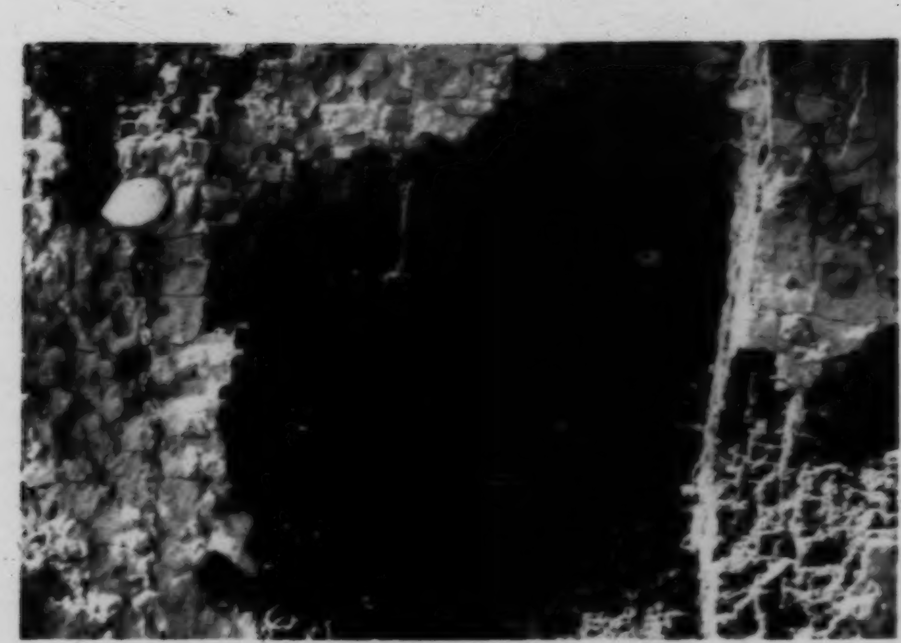
A Outcrop of the Grand Centre Formation and the top of the Marie Creek Formation. Note the highly oxidized olive brown color of the Marie Creek Formation. Section LA 81-1 (LSD 16 Sec. 19 Tp 63 Rg 2 W4M).

ASAHI
PENTAX

B Close up view of freshly exposed oxidized till, Marie Creek Formation. Note iron staining along fracture planes. Section SRA 200 (LSD 11 Sec.1 Tp 63 Rg 3 W4M).

COLOURED PICTURES
Images en couleur

Plate 2

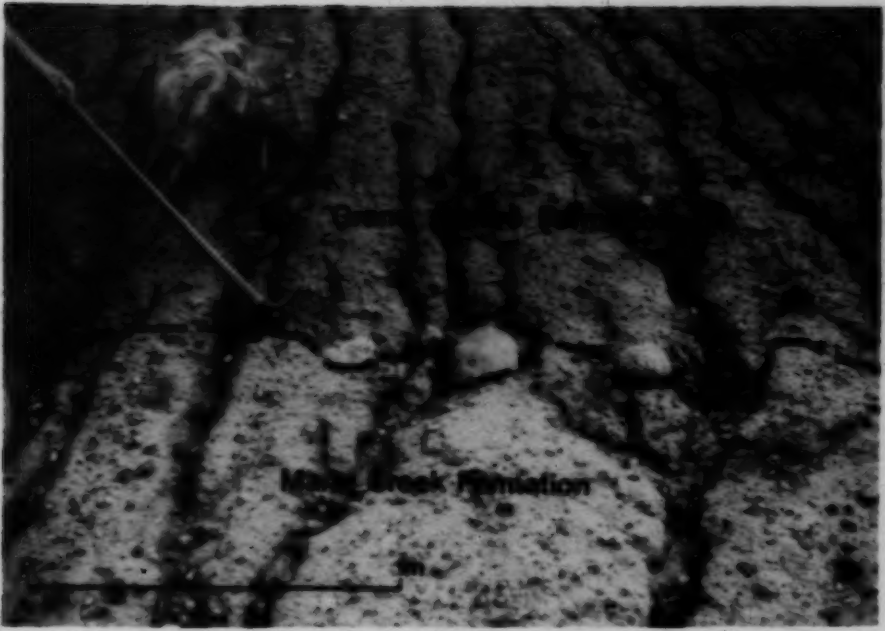


A Blocky, fractured structure of the till in the upper, oxidized portion of the Marie Creek Formation. Section SRA 200 (LSD 11 Sec. 1 Tp 63 Rg 3 W4M).

B Iron staining along widely spaced joints in till of the lower, unoxidized portion of the Marie Creek Formation. Section SRA 200 (LSD 11 Sec. 1 Tp 63 Rg 3 W4M).

COLOURED PICTURES
Images en couleur

Plate 3

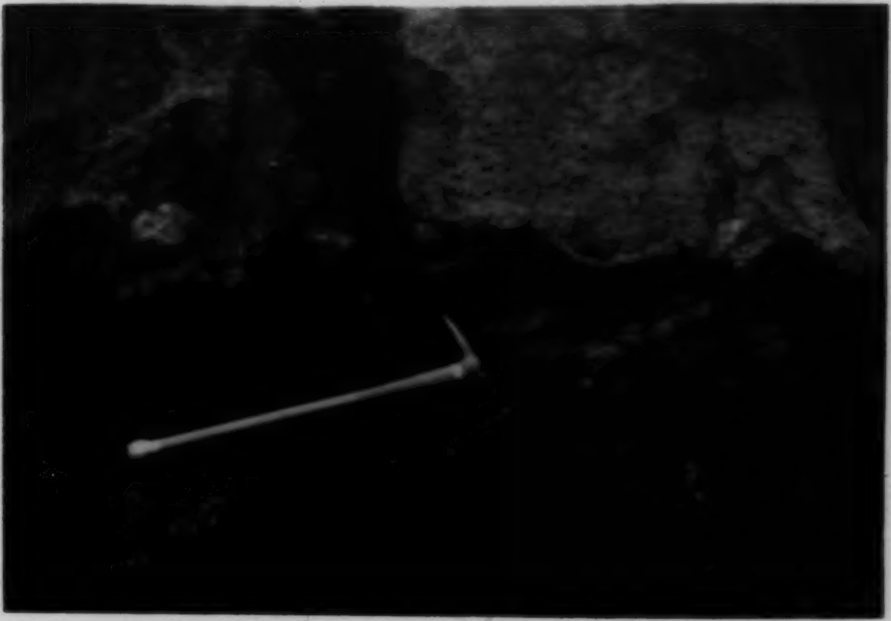


A Boulder concentration along the contact of the Grand Centre Formation and Marie Creek Formation. Section LA 81-1 (LSD 16 Sec. 19 Tp 63 Rg 2 W4M).

B Boulder concentration within the Marie Creek Formation. Section SRA 200 (LSD 11 Sec. 1 Tp 63 Rg 3 W4M).

COLOURED PICTURES
Images en couleur

Plate 4



A Nearly horizontal lenses of sand interbedded with till, Marie Creek Formation. Section SRA 200 (LSD 11 Sec. 1 Tp 63 Rg 3 W4M).

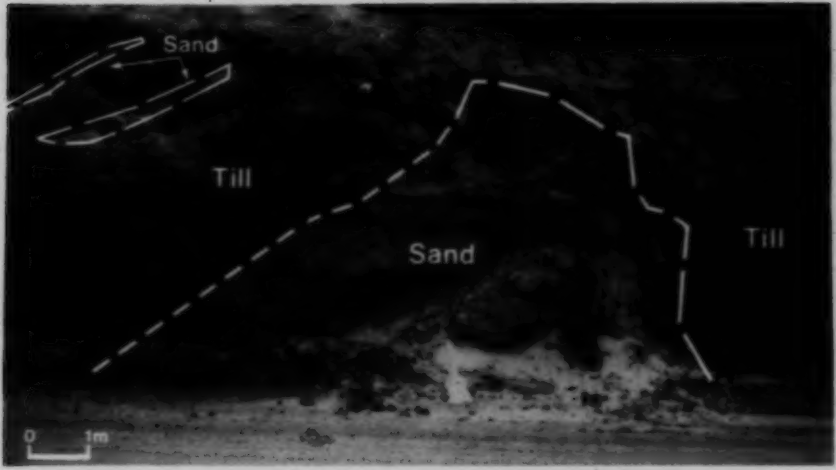
B Irregularly shaped inclined lenses of sand within till of the Marie Creek Formation. Section SRA 200 (LSD 11 Sec. 1 Tp 63 Rg 3 W4M).

COLOURED PICTURES
Images en couleur

Plate 5

A Glacially displaced shale within the Hilda Lake Member of the Grand Centre Formation. Note overturned bed of light colored bentonite. Section SRA 47 (LSD 15 Sec. 36 Tp 62 Rg 2 W4M).

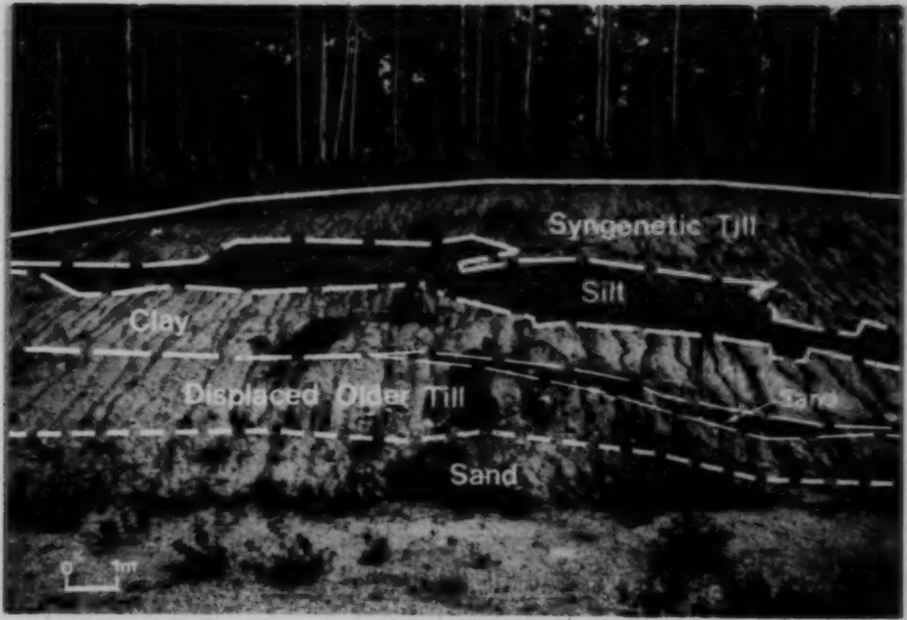
B Glacially displaced shale and ironstone within the Hilda Lake Member, Grand Centre Formation. Section SRA 250 (LSD 5 Sec. 26 Tp 60 Rg 3 W4M).



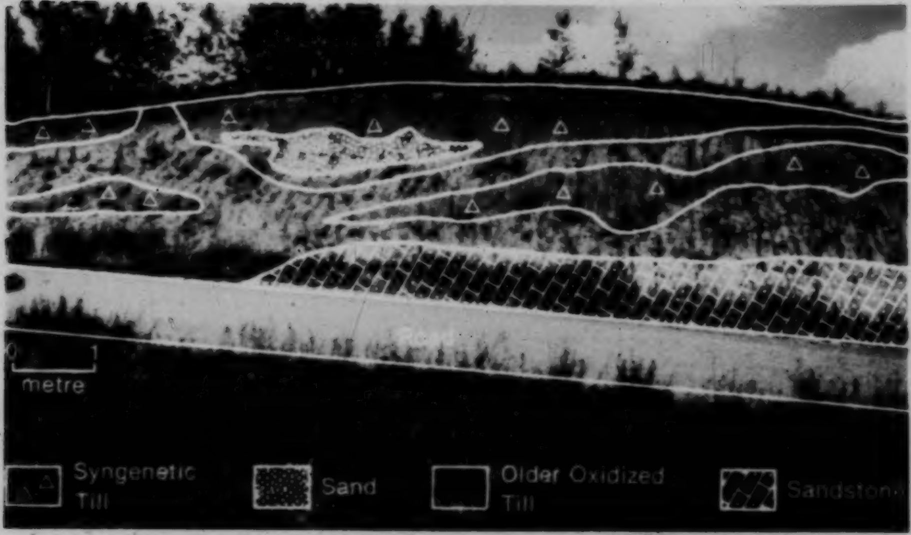
C Glacially displaced stratified sediment within the Hilda Lake Member, Grand Centre Formation. Note steeply folded beds of sand. (LSD 13 Sec.21 Tp 60 Rg 2 W4M).

COLOURED PICTURES
Images en couleur

Plate 6


Syngenetic Till
Silt
Clay
Displaced Older Till
Sand
Sand
0 1m

A Attentuated beds of glacially displaced sediment within the Vilna Member, Grand Centre Formation. Section LA 77 - 114 (LSD 15 Sec.13 Tp 69 Rg 13 W4M).


Road
0 1
metre
Syngenetic Till
Sand
Older Oxidized Till
Sandstone

B Irregularly shaped masses of glacially displaced sediment within the Vilna Member, Grand Centre Formation. Section MF 77 - 137 (LSD 14 Sec. 24 Tp 59 Rg 10 W4M).

COLOURED PICTURES
Images en couleur

XV. APPENDICES

A. Appendix A: Lithology and laboratory analyses of Alberta Geological Survey auger testholes.

B. Appendix B: Clay mineralogy of representative samples from till formations, Sand River map area.

C. Appendix C: Variations with depth in the composition of the very coarse sand fraction.

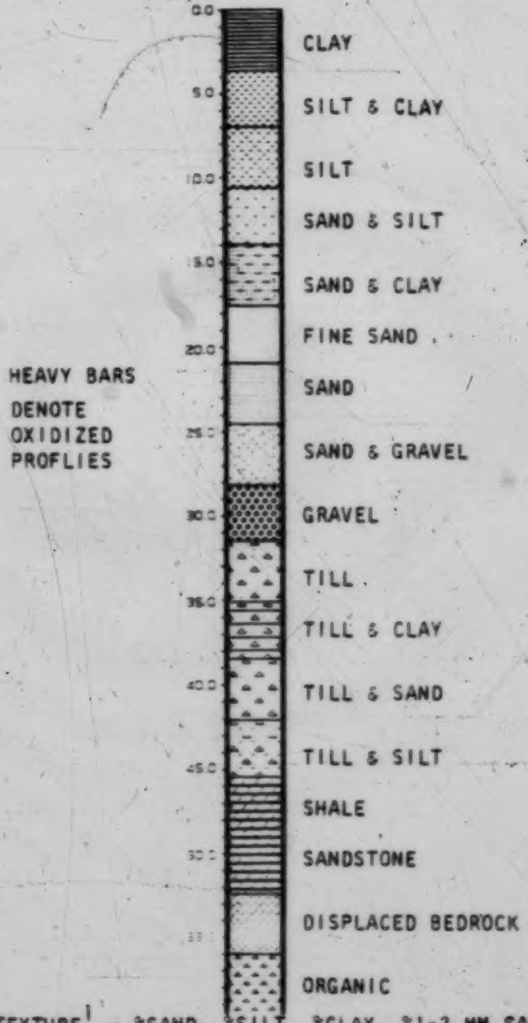
D. Appendix D: Description of field observations, and laboratory procedures.

A. Appendix A: Lithology and laboratory analyses of Alberta Geological Survey auger testholes

LEGEND FOR TESTHOLE LITHOLOGIES AND SAMPLE ANALYSES

TESTHOLE NAME - LOCATION - ELEVATION - DATE DRILLED

FORMATION NAME	DEPTH (METRES)	LITHOLOGY	TEXTURE[1]	MATRIX[2] CARBONATE	COARSE SAND[3] LITHOLOGY


0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
CLAY
SILT & CLAY
SILT
SAND & SILT
SAND & CLAY
FINE SAND
SAND
SAND & GRAVEL
GRAVEL
TILL
TILL & CLAY
TILL & SAND
TILL & SILT
SHALE
SANDSTONE
DISPLACED BEDROCK
ORGANIC
HEAVY BARS
DENOTE
OXIDIZED
PROFLIES

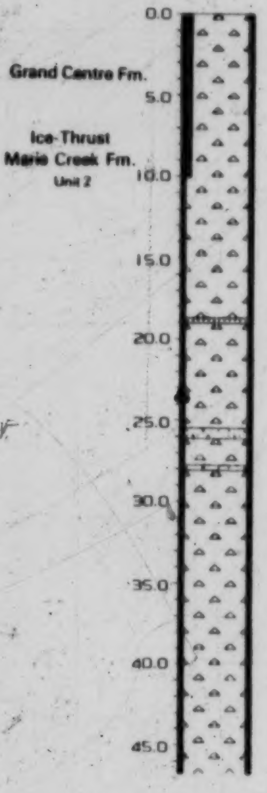
TEXTURE[1] - %SAND, %SILT, %CLAY, %1-2 MM SAND, % MOISTURE CONTENT

MATRIX CARBONATE[2] - VOLUME CO_2, %CO_3, CALCITE/DOLOMITE RATIO

COARSE SAND LITHOLOGY[3] - IGN-METH = %IGNEOUS & METAMORPHIC ROCKS, QTZ = %QUARTZ, QTZT-QSS = %QUARTZITE & QUARTZ SANDSTONE, LST = %LIMESTONE, DST = %DOLOSTONE, LOC = %LOCAL BEDROCK (SHALE, SILTSTONE, SANDSTONE, IRONSTONE), OTH = %OTHER ROCKS, N = TOTAL NUMBER OF GRAINS

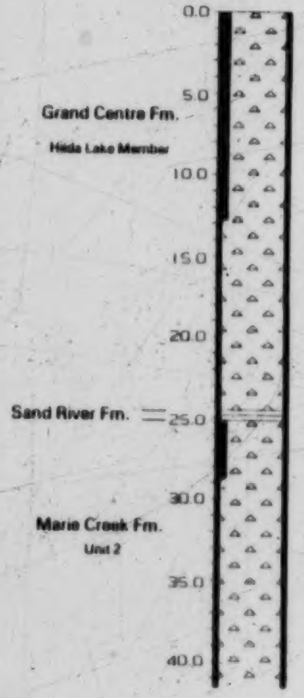
T1

Alberta Geological Survey Testhole 1 1
Location SE of LSD 14 Sec 27 Twp 66 Rng 1 W of 4 Mer . NTS 73L
Elevation 2190 Ft 668 M Source 1:50,000 NTS 73L/9
Date drilled 197510 25 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	COARSE SAND LITHOLOGY (%) IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	38.0	23.0	39.0	42.0	24.0	34.0	2.49	13.7				56.0	32.0	4.0	2.0	2.0	3.0	0.0	308
3.00	41.0	24.0	35.0	45.0	25.0	30.0	2.58	9.6				56.0	34.0	23.0	2.0	5.0	0.6	0.0	338
4.00	40.0	28.0	32.0	44.0	28.0	27.0	2.46	10.0				51.0	32.0	35.0	4.0	7.0	1.2	0.0	342
5.00	41.0	25.0	33.0	45.0	26.0	29.0	2.43	11.6				45.0	35.0	1.4	3.0	7.0	2.0	0.0	298
7.00	39.0	27.0	34.0	41.0	29.0	30.0	5.70	9.4				45.0	37.0	7.6	2.0	7.0	1.2	0.0	344
8.00	41.0	28.0	31.0	43.0	30.0	27.0	4.41	8.7				51.0	30.0	6.3	3.0	9.0	1.5	0.0	342
9.00	40.0	28.0	32.0	44.0	29.0	27.0	2.81	8.2				63.0	21.0	4.0	3.0	7.0	1.2	0.0	338
10.00	41.0	28.0	31.0	45.0	28.0	27.0	2.50	8.2				58.0	27.0	2.3	5.0	6.0	2.1	0.0	345
11.00	41.0	26.0	33.0	44.0	27.0	29.0	2.51	9.0				57.0	26.0	2.3	5.0	8.0	2.4	0.0	326
12.00	43.0	26.0	31.0	47.0	27.0	26.0	3.16	8.6				55.0	24.0	6.3	6.0	8.0	1.6	0.0	401
13.00	44.0	25.0	31.0	47.0	26.0	27.0	2.77	9.1				59.0	25.0	5.6	4.0	6.0	0.6	0.0	364
14.00	42.0	27.0	31.0	46.0	28.0	26.0	2.83					62.0	24.0	2.0	4.0	8.0	0.8	0.0	376
17.00	43.0	26.0	30.0	46.0	28.0	26.0	2.99	9.1				60.0	23.0	5.0	4.0	8.0	0.6	0.0	401
18.00	45.0	28.0	27.0	50.0	28.0	23.0	3.38	9.2				56.0	26.0	3.5	6.0	6.0	1.8	0.0	436
18.50								12.4											
19.00	49.0	26.0	26.0	52.0	28.0	21.0	2.84	10.3				57.0	29.0	5.5	4.0	5.0	0.3	0.0	368
21.00	46.0	25.0	29.0	49.0	27.0	24.0	2.83	10.0				52.0	29.0	7.3	5.0	4.0	1.8	0.0	380
22.00	46.0	27.0	27.0	50.0	28.0	21.0	3.00	10.1				51.0	32.0	7.7	3.0	3.0	3.5	0.0	408
23.00	41.0	29.0	30.0	46.0	30.0	24.0	2.54	10.0				50.0	28.0	5.6	6.0	5.0	3.3	0.0	343
24.00	43.0	30.0	27.0	46.0	31.0	23.0	2.51	10.7				48.0	33.0	8.9	4.0	6.0	0.6	0.0	326
25.00	48.0	27.0	25.0	52.0	28.0	20.0	3.16					57.0	28.0	5.2	4.0	3.0	1.4	0.0	412
26.00	56.0	24.0	20.0	59.0	24.0	17.0	3.85	10.4				60.0	27.0	5.4	3.0	5.0	1.2	0.0	507
27.00	50.0	26.0	24.0	55.0	26.0	20.0	4.39	10.9				64.0	23.0	6.0	3.0	5.0	0.2	0.0	513
28.00	49.0	25.0	25.0	53.0	27.0	20.0	3.38	11.4				57.0	30.0	2.8	4.0	4.0	1.8	0.0	400
29.00	49.0	27.0	24.0	53.0	26.0	21.0	2.81	10.8				59.0	29.0	2.5	5.0	3.0	1.8	0.0	382
31.00	49.0	25.0	25.0	53.0	25.0	23.0	3.20	10.3				62.0	27.0	1.5	4.0	3.0	1.9	0.0	412
33.00	49.0	28.0	24.0	53.0	26.0	21.0	3.14	9.8				58.0	32.0	1.1	3.0	4.0	2.1	0.0	399
33.50	51.0	26.0	24.0	54.0	26.0	21.0	2.97	9.0				60.0	30.0	1.5	4.0	3.0	0.8	0.0	383
34.00	47.0	29.0	25.0	51.0	27.0	22.0	3.17	9.1				61.0	30.0	2.5	3.0	2.0	0.3	0.0	420
35.00	48.0	25.0	27.0	52.0	25.0	23.0	3.19	9.1				59.0	28.0	3.0	5.0	5.0	1.4	0.0	405
36.00	48.0	25.0	27.0	52.0	27.0	22.0	3.19	9.5				59.0	28.0	3.7	3.0	5.0	1.5	0.0	405
37.00	47.0	26.0	28.0	51.0	28.0	22.0	3.04	9.4				57.0	31.0	5.0	4.0	3.0	1.0	0.0	404
38.00	47.0	25.0	29.0	50.0	28.0	22.0	3.25	8.6				56.0	32.0	5.0	4.0	4.0	0.9	0.0	412
39.00	45.0	26.0	29.0	49.0	27.0	23.0	3.20	9.5				60.0	29.0	4.0	2.0	5.0	0.8	0.0	394
40.00	47.0	25.0	28.0	50.0	27.0	23.0	3.20	9.4				63.0	27.0	4.0	2.0	3.0	0.8	0.0	389
42.00	46.0	26.0	29.0	50.0	28.0	23.0	2.90	10.0				62.0	25.0	4.0	4.0	3.0	1.8	0.0	391
42.50	47.0	24.0	29.0	50.0	27.0	23.0	3.07	8.6				61.0	25.0	7.0	3.0	3.0	2.5	0.0	398
43.00	45.0	25.0	29.0	48.0	27.0	24.0	2.90	8.9				55.0	33.0	5.3	4.0	2.0	1.0	0.0	379
44.00	47.0	24.0	29.0	50.0	27.0	24.0	3.01	9.6				57.0	27.0	9.0	4.0	3.0	0.8	0.0	388
46.00	45.0	26.0	30.0	49.0	28.0	23.0	3.02	9.8				61.0	26.0	6.0	3.0	3.0	1.1	0.0	388

T2

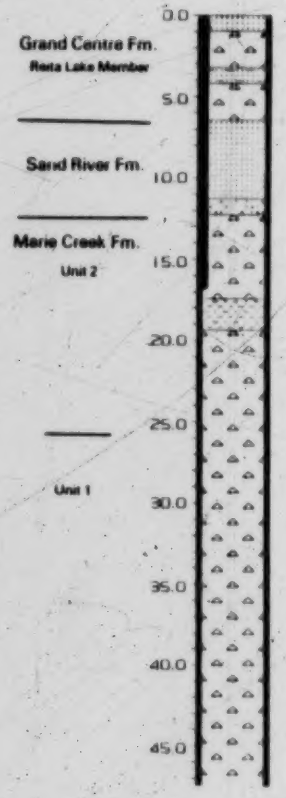


Alberta Geological Survey Testhole - T 2
Location of LSD 4 Sec 15 Twp 65 Rng 2 W of 4 Mer NTS 73L
Elevation 1900 Ft 579 M Source 1 50,000 NTS 73L/9
Date drilled 197510 28 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METH	QTZ	QTZT QSS	LST	DST	EDC	OTH	N
1 00	28 0	31 0	42 0	31 0	33 0	36 0	0 83	16 6				62 7	25 4	4 4	3 1	2 7	1 8	0 0	552
2 50	26 0	34 0	41 0	30 0	36 0	34 0	0 46	16 0				53 0	27 7	7 2	0 0	3 6	9 6	0 0	83
3 00	27 0	31 0	42 0	31 0	33 0	36 0	0 75	15 0				66 5	24 3	3 9	1 0	1 8	2 4	0 0	510
4 00	26 0	31 0	44 0	30 0	33 0	37 0	0 78	15 5				61 0	26 9	0 8	0 0	2 5	8 4	0 0	119
5 00	28 0	28 0	44 0	31 0	31 0	38 0	0 76	15 1				62 4	21 5	3 1	1 3	4 0	7 5	0 0	452
7 00	27 0	31 0	43 0	31 0	33 0	36 0	0 70					64 8	26 9	4 9	1 6	1 0	0 8	0 0	386
7 50	26 0	33 0	41 0	30 0	35 0	35 0	0 72	14 6				62 4	21 4	12 0	1 7	2 6	0 9	0 0	117
8 50	26 0	30 0	44 0	30 0	32 0	38 0	0 72	14 2				63 8	28 4	2 0	2 8	2 3	0 6	0 3	356
9 00	28 0	28 0	44 0	31 0	31 0	38 0	0 74	14 1				59 3	18 9	2 6	0 7	1 8	1 1	15 4	455
10 00	26 0	30 0	43 0	31 0	32 0	37 0	0 73	14 0				65 8	20 9	3 2	1 3	1 5	1 3	5 5	474
11 00	28 0	28 0	44 0	31 0	32 0	37 0	0 72	13 8				58 4	27 0	6 7	3 4	3 4	1 1	0 0	89
13 00	27 0	28 0	45 0	31 0	31 0	38 0	1 02	14 3				67 8	22 5	4 4	2 3	1 1	0 6	0 0	565
14 00	28 0	28 0	44 0	31 0	32 0	37 0	0 67	14 3				68 4	24 5	1 0	1 0	3 1	1 0	0 0	98
15 00	28 0	28 0	44 0	31 0	32 0	37 0	0 77	14 1				72 1	22 5	0 9	0 9	1 8	1 8	0 0	111
17 00	28 0	26 0	46 0	31 0	31 0	38 0	0 70	14 5				71 4	17 5	4 0	2 7	1 9	2 5	0 0	371
18 00	27 0	28 0	45 0	31 0	32 0	37 0	0 88	14 1				68 7	21 2	5 0	2 0	3 0	0 0	0 0	99
19 00	27 0	28 0	46 0	32 0	31 0	37 0	0 99	14 2				65 5	26 7	3 6	2 9	0 9	1 3	0 0	660
20 00	29 0	28 0	43 0	32 0	32 0	36 0	1 34	13 4				65 6	25 8	3 0	2 5	1 8	1 0	0 3	395
21 00	26 0	30 0	44 0	30 0	33 0	37 0	0 97	14 1				70 1	24 2	2 4	2 4	0 0	0 8	0 0	124
22 00	28 0	27 0	44 0	31 0	32 0	37 0	0 91	14 1				73 2	21 1	2 7	0 8	1 6	0 6	0 0	489
23 00	26 0	30 0	44 0	30 0	33 0	37 0	0 63	13 7				75 7	20 2	1 6	1 6	0 7	0 0	0 2	440
24 00	7 0	12 0	81 0	8 0	19 0	73 0	0 25	21 5											
26 00	40 0	29 0	31 0	45 0	28 0	27 0	3 42	10 0				57 2	20 6	1 1	5 5	14 2	1 7	0 0	360
27 00	47 0	26 0	27 0	50 0	26 0	24 0	3 33	8 7				60 1	29 4	1 6	4 0	3 1	1 8	0 0	449
28 00	43 0	27 0	30 0	48 0	26 0	26 0	3 41	9 1				61 4	27 0	1 5	4 2	3 4	2 5	0 0	474
29 00	45 0	26 0	30 0	48 0	26 0	26 0	3 57	8 2				57 5	31 6	0 9	3 5	4 8	1 7	0 0	459
30 00	42 0	26 0	32 0	46 0	26 0	28 0	2 72	10 0				64 4	25 3	1 0	4 3	3 1	1 5	0 0	419
32 00	44 0	24 0	33 0	47 0	25 0	28 0	3 11	10 0				64 0	25 8	0 4	4 9	4 2	0 6	0 0	450
34 00	48 0	27 0	25 0	52 0	27 0	21 0	3 26	9 8				58 9	30 5	1 1	4 4	2 7	2 2	0 0	452

T3

Alberta Geological Survey Testhole T 3
Location SE of LSD 8 Sec 36 Twp 61 Rng 1 W of 4 Mer , NTS 73L
Elevation 1775 Ft , 541 M ' Source 1:50 000 NTS 73L/8
Date drilled 197606 01 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00																			
2.00	44.3	24.5	31.2	48.0	24.0	28.0	2.14	10.8				66.3	25.9	1.3	1.3	4.2	0.3	0.0	309
3.00	38.4	30.5	31.1	43.3	29.4	27.3	1.08	11.5				61.1	28.1	5.8	0.0	2.9	0.0	0.0	139
3.50								16.9											
5.00	50.1	17.0	32.9	51.4	19.2	29.5	2.13	13.1				64.3	27.0	1.3	3.3	1.7	1.7	0.0	300
6.00	42.8	23.3	33.9	46.9	21.7	31.3	2.46	14.6				67.4	23.6	0.7	2.3	5.3	0.3	0.0	301
12.50	44.2	29.1	26.7	47.8	29.1	23.0	2.98	11.3				58.3	20.4	0.3	4.1	15.5	1.1	0.0	367
14.00	45.3	30.2	24.5	49.4	29.5	21.1	2.96	11.1				55.5	19.1	1.5	5.8	16.5	0.9	0.0	346
15.00	46.5	30.3	23.2	50.5	29.6	20.0	2.91	10.5				55.0	20.3	1.1	5.0	16.4	1.9	0.0	360
17.00	47.6	29.5	22.9	51.9	28.1	20.0	2.98	10.4				54.8	23.4	0.5	4.1	15.0	1.4	0.0	367
18.00	56.2	22.5	21.3	59.1	22.6	18.4	3.46	16.8				60.2	29.2	1.7	3.1	4.2	1.4	0.0	425
20.00	42.7	32.0	25.3	47.1	31.0	21.9	3.25	10.1				58.1	24.6	1.3	4.4	10.2	0.8	0.0	391
21.00								8.2											
23.00	43.4	24.8	31.7	46.9	26.8	26.3	2.60	10.0				53.8	33.1	0.6	5.6	4.5	2.3	0.0	357
24.00	48.9	24.4	26.7	52.8	25.1	22.0	3.68	12.7				56.9	29.9	0.5	3.8	3.8	4.1	0.0	448
26.00	34.1	25.7	40.2	37.4	31.1	31.5	2.25	12.6				46.0	30.5	0.3	9.5	4.0	9.1	0.0	328
27.00	30.0	30.3	39.7	33.8	35.5	30.7	2.02	12.7				48.4	27.5	1.1	6.6	2.8	13.3	0.0	287
29.00	31.6	27.7	40.6	34.6	34.8	30.6	2.13	12.7				41.3	34.4	0.7	8.2	2.6	11.8	0.0	305
30.00	37.7	26.4	35.9	41.1	31.8	27.1	2.92	13.3				48.0	33.9	0.8	4.7	4.2	7.2	0.0	381
32.00	28.4	32.1	39.5	31.4	39.9	28.7	2.08	13.5				40.3	37.8	0.4	9.0	5.0	6.1	0.0	278
33.50	35.5	27.8	36.7	38.9	32.4	28.7	3.49	12.7				54.5	25.1	1.3	5.9	4.4	9.2	0.0	455
35.00	35.8	25.9	38.3	38.9	31.4	29.6	2.71	11.9				49.6	32.0	0.3	6.5	4.7	8.2	0.0	341
36.50	39.5	27.9	32.6	43.2	30.4	26.5	3.33	11.3				48.2	35.8	0.4	6.0	2.4	6.9	0.0	452
38.00	34.0	26.9	39.0	37.2	31.8	31.0	2.48	12.5				49.5	30.6	0.0	6.1	3.4	10.4	0.0	327
39.50	34.8	27.1	38.1	38.4	31.2	30.3	2.13	11.8				42.7	38.4	0.0	6.4	1.4	10.3	0.0	281
41.00	34.7	26.0	39.2	37.8	29.6	32.6	2.28	13.0				45.3	34.5	0.0	9.1	4.6	7.2	0.0	307
42.50	33.6	28.7	37.7	37.0	31.9	31.1	1.86	12.2				[illegible]	31.6	0.0	8.2	4.1	4.9	0.0	269
44.00	36.5	28.7	34.8	39.7	32.8	27.5	1.89	12.6				51.4	32.2	0.0	5.5	3.5	5.5	0.0	255
46.00	31.4	30.6	38.1	34.8	34.0	31.2	1.73	11.7				48.2	27.5	0.5	10.6	6.9	5.6	0.0	218
47.00	38.1	26.4	35.5	41.0	31.0	28.0	1.88	13.2				47.2	30.9	0.0	10.4	7.8	2.6	0.0	269

T4

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Alberta Geological Survey Testhole  T 4
Location      of LSD 10 Sec 17 Twp  58 Rng  3 W of 4 Mer  .  NTS  73L
Elevation   2075 Ft     633 M   Source  1 50,000 NTS 73L/
Date drilled    197510 29  Logged by  ANDRIASHEK

                    TEXTURE (%)                              MATRIX CARBONATE          COARSE SAND LITHOLOGY (%)
 DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H2O    CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
  (M) >62.5um     <4um  >50um      <2um 1-2mm   (%)   (cc)  (%)          METM        QSS
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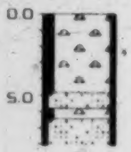
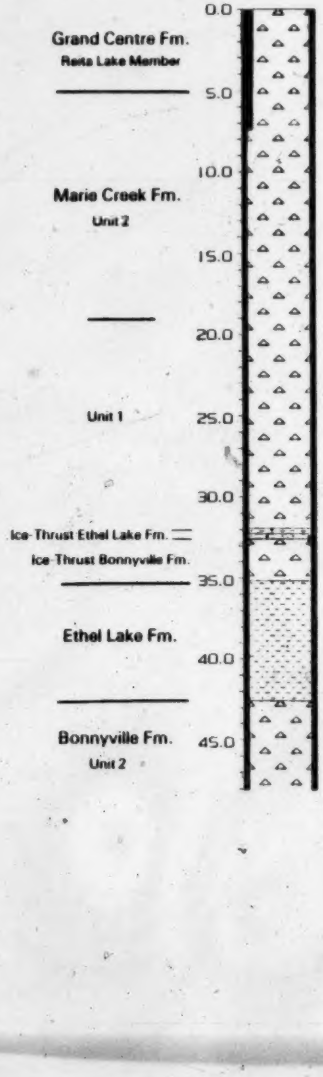


T5

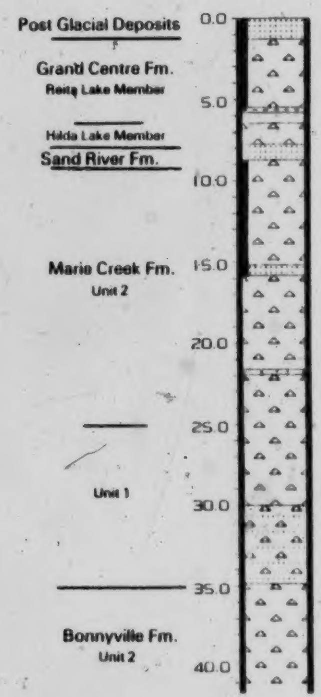
Alberta Geological Survey Testhole : T 5
Location : of LSD 2 Sec 16 Twp 59 Rng 1 W of 4 Mer , NTS 73L
Elevation 2070 Ft 631 M Source 1 50,000 NTS 73L/1
Date drilled 197510 29 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	35.0	28.0	38.0	39.0	29.0	32.0	1.36	15.1	30.7	12.9	0.39	70.9	21.4	1.1	3.9	1.7	1.7	0.0	182
2.00	36.0	26.0	38.0	39.0	29.0	33.0	1.28	15.7	29.9	12.6	0.39	68.5	25.4	0.0	2.2	2.2	1.1	0.0	181
3.00	34.0	28.0	39.0	38.0	28.0	33.0	1.51	15.6	28.6	12.0	0.30	70.9	22.6	1.0	1.5	1.[illegible]	1.0	0.0	199
4.00	33.0	25.0	42.0	36.0	28.0	37.0	1.32	16.1	26.1	10.9	0.25	63.0	28.7	1.7	2.2	4.4	0.0	0.0	181
5.00	37.0	23.0	40.0	41.0	24.0	35.0	2.13	15.0	26.5	11.1	0.28	60.3	30.6	0.3	4.4	3.7	1.3	0.0	297
6.00	37.0	33.0	30.0	41.0	34.0	25.0	2.92	10.0	48.5	20.2	0.16	55.8	17.6	0.0	4.4	18.4	1.3	3.4	387
7.00	37.0	34.0	29.0	40.0	38.0	23.0	2.91	8.9				60.7	20.5	0.9	5.4	11.4	1.2	0.0	351
8.00	38.0	32.0	30.0	41.0	35.0	24.0	2.81	8.9	44.3	18.4	0.14	63.3	21.8	0.3	4.6	9.4	0.9	0.0	330
9.00	32.0	35.0	33.0	36.0	39.0	25.0	2.48	9.7				63.0	19.9	0.3	3.9	11.4	1.3	0.0	306
10.00	39.0	34.0	27.0	43.0	35.0	22.0	3.15	8.5	46.7	19.4	0.12	57.9	20.7	1.0	4.3	14.4	1.6	0.0	416
11.00	39.0	34.0	27.0	43.0	34.0	23.0	3.49	8.8				61.2	21.3	1.2	3.9	11.1	1.4	0.0	441
12.00	37.0	35.0	27.0	42.0	35.0	23.0	2.86	8.3	47.9	20.0	0.20	56.6	19.7	0.6	7.4	13.4	0.3	0.0	366
13.00	44.0	32.0	23.0	48.0	33.0	19.0	4.82	9.4				61.6	20.1	0.6	4.9	11.8	0.5	0.0	568
14.00	38.0	35.0	27.0	42.0	35.0	23.0	2.77	8.9	47.0	19.6	0.23	61.0	19.2	0.6	4.2	14.5	0.6	0.0	359
14.50	39.0	32.0	30.0	42.0	33.0	25.0	2.88	9.2				61.2	20.9	0.6	5.2	9.9	1.9	0.0	363
15.00	36.0	38.0	26.0	42.0	36.0	22.0	2.46	9.1	47.5	19.7	0.11	58.4	26.3	1.2	2.9	10.8	0.3	0.0	315
17.00	42.0	31.0	27.0	46.0	32.0	23.0	3.33	8.3				61.7	25.6	0.9	3.2	7.9	0.7	0.0	407
18.00	39.0	33.0	28.0	44.0	33.0	23.0	3.21	10.3	43.3	18.0	0.15	63.7	20.0	0.9	4.0	10.4	1.0	0.0	424
19.00	36.0	30.0	35.0	39.0	34.0	28.0	2.33	9.6	38.6	16.1	0.21	64.9	21.9	0.6	3.6	8.9	0.3	0.0	302
21.00	33.0	32.0	35.0	38.0	34.0	28.0	2.50		36.8	15.4	0.20	67.9	20.7	1.0	2.6	5.6	1.6	0.0	305
21.50	33.0	32.0	35.0	36.0	36.0	29.0	1.98	10.4	37.7	15.8	0.21	64.3	22.5	2.0	2.3	7.4	0.4	0.0	258
23.00	31.0	32.0	37.0	35.0	36.0	30.0	2.36	9.5	35.9	14.9	0.16	63.5	23.2	0.3	2.5	8.6	0.9	0.0	315
24.00	32.0	32.0	36.0	35.0	35.0	30.0	2.49	12.7	41.8	17.5	0.24	61.9	16.8	0.9	4.8	13.5	1.3	0.0	310
25.00	35.0	31.0	34.0	38.0	36.0	26.0	2.44	11.3	43.6	18.2	0.17	57.4	26.8	0.3	3.9	11.0	0.6	0.0	310
26.00	33.0	32.0	35.0	37.0	36.0	27.0	2.43	11.0	40.9	17.1	0.22	65.0	21.1	0.0	2.2	8.8	2.5	0.0	317
27.00	35.0	31.0	34.0	38.0	36.0	26.0	2.29	10.7	39.6	16.5	0.18	63.6	19.9	0.6	3.8	9.6	1.7	0.0	291
28.00	35.0	30.0	34.0	39.0	34.0	27.0	2.79	11.2	45.9	19.1	0.17	62.8	17.9	0.6	5.5	11.1	1.6	0.0	379
29.00	27.0	38.0	35.0	29.0	44.0	27.0	1.62	11.9	34.2	14.2	0.14	64.2	28.8	0.4	1.8	3.5	1.2	0.0	226
30.00	30.0	36.0	34.0	34.0	40.0	27.0	2.41	11.9	39.3	16.3	0.11	62.4	22.6	1.0	1.7	8.7	2.4	0.0	287
31.00	28.0	35.0	37.0	31.0	39.0	30.0	1.57	12.9	39.3	16.3	0.12	64.8	21.8	0.0	3.1	9.3	0.5	0.0	193
32.00								12.7											
33.00	46.0	26.0	28.0	50.0	27.0	23.0	2.99	11.3	23.5	9.9	0.39	57.4	33.3	2.3	2.5	1.8	2.8	0.0	399
34.00	47.0	25.0	28.0	51.0	30.0	20.0	2.82	10.6	23.9	10.0	0.27	56.4	32.5	0.5	4.3	3.5	2.3	0.0	369
35.00	46.0	25.0	29.0	50.0	29.0	21.0	2.93	10.1	23.8	10.0	0.35	52.1	37.3	1.9	4.8	2.9	1.1	0.0	378
36.00								15.9											
37.00								15.6											
38.00								16.0											
39.00								15.8											
40.00								16.4											
41.00								15.8											
42.00								15.4											
43.00	33.0	30.0	37.0	37.0	33.0	30.0	1.47	12.9	20.3	8.6	0.37	58.4	31.5	2.5	3.6	1.5	2.5	0.0	197
44.00	38.0	27.0	35.0	41.0	32.0	27.0	1.89	14.0	19.7	8.3	0.38	54.0	36.8	1.4	1.8	3.7	1.6	0.0	272
45.00	37.0	28.0	35.0	42.0	33.0	26.0	2.32	11.2	20.5	8.7	0.54	57.9	33.4	1.0	4.2	1.6	1.6	0.0	311
46.00	37.0	27.0	36.0	41.0	32.0	27.0	2.13	11.0	22.0	9.3	0.41	63.8	26.5	1.7	4.9	2.1	1.0	0.0	287

T6

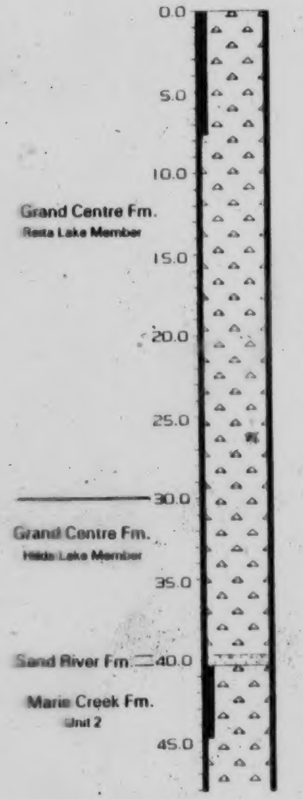
Alberta Geological Survey Testhole T 6
Location of LSD 15 Sec 31 Twp 62 Rng 3 W of 4 Mer NTS 73L
Elevation 1775 Ft 541 M Source 1 50,000 NTS 73L/8
Date drilled 197510 29 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	COARSE SAND LITHOLOGY (%) IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00																			
2.00	33.0	28.7	38.3	36.4	33.6	30.0	1.93	14.6	23.1	9.7	0.35	77.6	18.5	1.6	1.2	0.4	0.8	0.0	254
3.00	36.8	23.9	39.3	40.1	27.6	32.4	2.03	15.1	19.3	8.1	0.34	75.3	19.1	1.1	1.5	1.9	0.8	0.0	267
4.00	36.9	24.6	38.5	40.4	28.2	31.3	1.77	15.0	24.4	10.2	0.24	76.9	19.7	0.8	0.4	1.7	0.4	0.0	234
5.00	34.2	29.7	36.1	38.2	32.7	29.1	1.07	14.6	26.5	11.1	0.24	78.3	18.1	0.7	1.5	0.7	0.7	0.0	138
6.00									29.4	12.2	0.15								
6.50	26.5	34.2	39.3	30.7	39.1	30.2	0.92	12.0	25.1	10.5	0.26	78.2	16.9	3.2	1.6	0.0	0.0	0.0	124
9.00	43.8	29.5	26.7	47.7	31.1	21.2	3.43	9.8	41.6	18.6	0.14	61.7	15.9	1.0	2.0	18.4	1.0	0.0	402
10.00	44.6	28.9	26.5	48.5	31.4	20.0	3.62	11.4	44.1	18.4	0.16	68.3	14.4	2.9	2.0	11.5	0.6	0.0	451
11.00	40.4	29.0	30.6	44.2	31.2	24.5	2.81	7.9	44.1	18.3	0.09	56.5	19.7	0.6	4.1	17.7	1.5	0.0	345
12.00	43.0	28.8	28.2	46.6	30.6	22.8	3.08	8.1	44.7	18.6	0.17	60.8	20.8	0.8	3.6	13.3	0.8	0.0	385
13.00	45.2	22.6	32.3	48.7	25.5	25.8	2.80	9.8	28.9	12.1	0.29	58.8	29.9	0.9	3.7	2.8	3.7	0.0	354
14.00	44.6	24.5	30.8	48.1	26.9	25.0	2.46	9.0	36.5	15.3	0.24	61.9	27.6	0.3	2.8	6.8	0.6	0.0	352
15.00	45.0	26.5	28.6	48.8	28.0	23.2	2.61	8.7	37.4	15.5	0.15	59.7	26.8	1.5	3.2	7.1	1.8	0.0	340
16.50	45.1	24.4	30.5	48.4	27.5	24.2	2.82	9.0	27.6	11.5	0.15	56.4	31.8	1.1	2.9	4.6	3.2	0.0	374
18.00	41.5	26.3	32.2	44.9	29.7	25.4	2.48	10.2	26.5	11.1	0.23	62.4	25.8	3.1	2.8	3.7	2.2	0.0	322
19.00	44.5	24.9	30.6	48.2	27.8	24.0	2.47	10.1	28.2	11.7	0.11	59.8	30.6	1.3	3.3	3.7	1.4	0.0	301
20.00	36.9	24.1	39.0	39.9	29.7	30.5	2.15	11.8	25.5	10.6	0.20	64.2	24.3	0.7	4.5	3.8	2.1	0.0	288
21.00	38.7	24.8	36.6	42.0	29.4	28.6	2.54	10.8	27.5	11.5	0.21	64.1	24.7	0.0	4.1	2.7	4.4	0.0	340
22.00	52.5	22.4	25.1	56.0	24.7	19.3	2.94	9.4	25.0	10.4	0.11	59.7	31.2	0.5	3.4	2.9	2.1	0.0	382
23.00	45.6	24.7	29.7	49.3	27.4	23.3	6.26	9.5	27.0	11.3	0.27	61.9	28.5	2.2	1.1	2.9	3.3	0.0	281
24.00	36.0	25.6	38.4	39.2	31.0	29.8	2.10	11.6	29.3	12.3	0.31	61.3	25.1	1.4	5.5	5.2	1.5	0.0	271
25.00	28.1	25.7	46.1	30.7	32.1	37.1	1.58	12.9	25.7	10.7	0.14	63.6	28.7	0.5	2.6	2.6	2.1	0.0	195
26.00	25.0	26.9	48.1	27.7	33.9	38.4	1.20	13.7	26.4	11.0	0.14	61.3	27.4	1.2	3.6	4.2	2.4	0.0	168
27.00	30.2	28.0	41.8	33.1	33.4	33.6	1.80	12.2	24.8	10.3	0.14	62.2	27.8	1.2	2.5	4.2	2.1	0.0	241
27.50	29.5	27.3	43.3	32.4	33.3	34.3	1.86	12.8	34.0	14.2	0.25	71.2	18.2	0.4	1.7	2.1	6.4	0.0	236
29.00	25.3	26.5	48.2	28.2	33.3	38.5	1.34	13.5	28.1	11.7	0.21	70.3	23.2	1.1	2.2	1.1	2.1	0.0	185
30.00									34.5	14.3	0.15								
30.50	22.7	27.1	50.3	25.2	34.7	40.1	1.30	13.6	26.8	11.3	0.24	51.2	32.5	0.0	6.0	7.2	2.4	0.0	166
31.00								13.7	30.9	12.9	0.27								
33.00	19.7	23.5	56.8	21.8	32.8	45.5	1.38	13.2	25.5	10.7	0.26	55.3	30.0	3.0	3.5	5.9	2.4	0.0	170
34.00	31.7	26.9	41.5	34.5	33.3	32.2	2.18	8.9	35.9	15.1	0.30	62.9	26.0	0.4	3.5	6.3	1.0	0.0	288
35.00	48.2	25.4	26.4	51.6	27.4	20.9	5.27	9.7	19.4	8.1	0.29	79.3	17.6	0.5	0.5	1.3	0.0	0.0	641
36.00	46.2	28.8	25.0	50.1	31.0	18.9	3.25	9.1	31.8	13.4	0.41	66.8	22.7	1.3	2.5	4.5	2.4	0.0	401
37.00	49.2	27.2	23.6	52.7	29.7	17.6	4.05	9.1	30.4	12.8	0.34	56.2	31.0	0.8	6.6	3.0	2.4	0.0	504
38.00	48.2	28.3	23.5	52.0	30.3	17.7	3.02	9.2	32.2	13.5	0.34	58.9	29.5	1.9	2.3	4.7	2.1	0.0	387
39.00	51.5	24.9	23.5	55.2	28.0	16.9	3.59	8.9	29.3	12.4	0.45	58.1	30.4	1.0	4.4	3.4	2.5	0.0	437
40.00	54.4	22.8	22.7	57.7	24.9	17.4	3.38	9.3	27.8	11.7	0.40	54.1	32.3	1.4	3.4	4.8	2.8	0.0	436
41.00	57.2	21.7	21.1	61.0	23.2	15.8	3.07	9.1	24.7	10.4	0.45	59.2	27.1	1.0	3.5	6.3	2.8	0.0	395

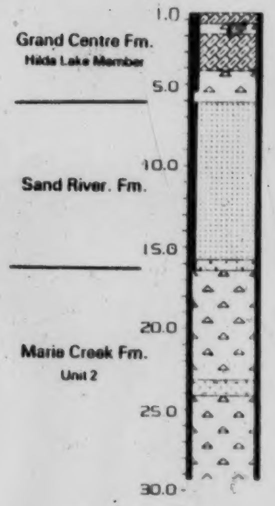
T7

Alberta Geological Survey Testhole . T 7
Location of LSD 4 Sec 1 Twp 63 Rng 6 W of 4 Mer NTS 73L
Elevation 1925 ft 587 M Source 1:50,000 NTS 73L/10
Date drilled 197510 30 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	TGN MEAN	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	36.4	26.5	37.1	40.4	28.2	31.4	1.57	12.5	31.1	[illegible]	0.30	68.4	22.1	2.0	1.1	3.1	1.0	0.0	196
2.00								13.3				66.2	28.0	1.3	1.8	0.9	1.0	0.0	224
3.00	34.6	24.7	40.7	37.5	28.1	34.4	1.51		26.9	11.2	0.22	70.1	26.4	0.0	1.2	1.7	0.0	0.6	174
4.00	36.4	25.6	38.0	40.3	27.4	32.3	1.74	14.0				65.8	24.0	0.9	4.0	1.8	3.6	0.0	225
5.00	31.7	24.6	43.7	34.3	28.4	37.3	1.52	14.4	25.8	10.8	0.22	65.6	26.3	1.6	2.1	3.8	0.5	0.0	186
6.00	30.1	24.7	45.1	33.5	28.8	37.7	1.10	15.9				75.2	22.0	2.1	0.0	0.0	0.7	0.0	141
7.00	28.3	23.5	48.1	30.7	27.3	42.0	1.11	15.5				70.2	24.1	2.5	0.6	1.8	0.0	0.6	162
8.00	21.4	36.5	42.2	25.6	38.7	35.7	0.52	14.2	25.6	10.7	0.26	70.3	20.3	3.1	4.7	1.6	0.0	0.0	64
9.00	33.0	31.8	35.2	37.3	33.6	29.1	1.45	13.9	28.2	11.8	0.29	74.9	22.0	1.6	0.5	0.5	0.5	0.0	191
10.00	32.7	30.9	36.5	36.0	34.3	29.7	1.41	12.9	27.7	11.6	0.25	72.3	23.9	1.6	1.1	1.1	0.0	0.0	184
10.50	32.9	33.8	33.3	37.5	34.6	27.9	1.28	11.7				73.7	21.7	1.1	1.7	1.1	0.0	0.6	175
12.00	38.5	31.0	30.5	43.9	31.0	25.1	1.75	11.0	29.5	12.4	0.28	73.2	25.1	0.4	0.9	0.4	0.0	0.0	231
13.00	37.9	33.2	28.9	42.8	33.1	24.1	1.80	11.5	30.0	12.5	0.24	63.1	27.1	1.8	2.2	3.5	2.2	0.0	225
14.00	41.4	26.4	32.2	45.3	28.3	26.4	2.16	10.9				66.3	29.2	1.9	1.1	1.5	0.0	0.0	264
15.00	39.3	30.3	30.3	44.7	29.4	25.9	1.96	10.9	25.3	10.5	0.20	64.0	32.4	0.4	1.2	1.6	0.4	0.0	250
16.00	41.1	26.9	32.0	44.8	29.0	26.2	2.10	9.8				67.7	25.6	1.1	0.7	2.6	2.3	0.0	266
17.00	39.8	29.5	30.8	43.1	31.4	25.5	1.68	9.7	28.9	12.1	0.18	71.5	25.2	0.9	0.9	1.4	0.0	0.0	218
18.00	34.7	32.3	33.0	39.1	34.4	26.5	1.38	10.8	29.3	12.2	0.20	65.2	29.8	0.6	0.0	3.4	1.2	0.0	178
19.00	34.5	31.0	34.4	38.1	32.9	29.0	1.31	11.7				79.4	17.6	1.2	1.2	0.6	0.0	0.0	165
20.00								11.6				80.7	21.1	1.6	3.2	3.2	0.4	0.0	220
21.00	21.8	27.8	50.3	24.7	33.0	42.3	1.01	12.7	25.0	10.4	0.16	69.9	25.2	0.0	0.8	2.4	1.6	0.0	123
21.50	25.5	29.9	44.6	28.1	34.0	37.9	1.00	13.3	28.7	12.0	0.21	73.7	20.3	1.5	1.5	3.0	0.0	0.0	133
23.00	32.6	30.3	37.1	37.0	34.1	31.6	1.45	11.8				71.2	23.4	0.5	2.2	2.7	0.0	0.0	184
24.50	34.2	30.9	34.9	37.7	32.8	29.5	1.17	11.2				67.1	27.6	0.6	1.3	2.6	0.0	0.0	192
25.00								11.2	29.2	12.2	0.25								
26.00	34.8	31.2	34.0	39.1	32.1	28.8	1.67	11.7				66.3	27.6	0.5	1.8	3.7	0.0	0.0	217
27.00	34.3	27.6	38.1	37.6	0.0	32.4	1.81	11.6	26.5	11.1	0.21	67.5	26.8	0.9	2.2	2.6	0.0	0.0	231
28.00	26.1	38.7	35.3	30.9	30.0	30.2	0.92	13.5				72.4	18.9	0.8	2.4	4.7	0.8	0.0	127
29.00	25.6	38.6	35.8	29.7	39.5	30.8	0.58	12.9	27.4	11.6	0.28	63.9	33.7	0.0	1.2	1.2	0.0	0.0	86
30.00	24.0	39.3	36.7	29.0	39.5	31.5	0.83	12.6	26.7	11.2	0.35	71.2	26.1	0.0	0.0	0.9	0.9	0.9	111
31.00	25.7	41.5	32.8	30.4	41.0	28.5	0.54	12.6				76.9	17.9	1.3	2.6	1.3	0.0	0.0	78
32.00	26.1	38.8	35.1	31.0	38.8	30.2	0.81	12.5	27.7	11.6	0.35	75.0	23.0	1.0	0.0	1.0	0.0	0.0	100
33.00	31.8	32.4	35.8	36.8	32.6	30.6	0.67	33.5	27.2	11.4	0.32	71.3	26.6	1.1	1.1	0.0	0.0	0.0	94
34.00	23.8	41.5	34.7	29.0	42.3	28.7	0.82	12.2				71.9	21.9	2.4	2.4	1.2	0.0	0.0	82
35.00	25.9	37.2	36.9	29.4	39.0	31.6	0.77	12.3	25.5	10.6	0.21	71.5	22.9	1.8	2.7	0.9	0.0	0.0	109
36.00	25.2	40.0	34.8	29.1	40.7	30.2	0.72	12.1	25.5	10.6	0.20	72.2	21.6	3.1	1.0	2.1	0.0	0.0	97
37.00	28.3	27.6	44.1	31.7	31.7	36.6	1.03	12.6				72.0	26.3	0.0	0.0	0.8	0.0	0.8	118
38.00	10.9	20.1	68.9	11.9	25.8	62.3	0.94	17.1	24.8	10.3	0.18	84.8	15.1	0.0	0.0	0.0	0.0	0.0	33
39.00	0.0	0.0	39.5	0.0	0.0	0.0	0.00	10.3	27.1	11.3	0.17								
40.00	36.7	32.4	30.9	40.6	32.4	27.0	3.01	10.8				53.9	16.6	0.0	6.6	19.6	3.3	0.0	362
41.00	37.1	33.1	29.8	41.3	32.8	25.9	2.42	10.8	45.8	19.1	0.18	52.1	24.1	0.3	3.2	19.9	0.3	0.0	307
42.00	39.6	29.1	31.3	42.9	31.0	26.1	2.68	10.4	42.5	18.5	0.17	54.7	20.6	0.0	5.9	16.5	2.4	0.0	340
43.50	38.2	32.5	29.3	42.5	33.8	23.7	2.63	10.0				57.9	21.2	0.3	2.0	17.6	0.9	0.0	340
44.00	40.0	29.7	30.3	43.2	31.8	25.0	2.93	10.7	40.7	16.9	0.15	59.1	21.2	0.0	4.1	14.7	0.9	0.0	320
45.00	38.2	32.0	29.8	42.5	33.0	24.5	2.40	10.5	45.0	18.7	0.13	59.1	23.1	0.3	3.3	12.4	1.7	0.0	298
46.00								10.3	43.5	18.1	0.16	57.8	21.5	0.1	4.5	14.9	0.8	0.0	340
48.00	57.9	12.3	29.8	61.1	14.4	24.5	2.45	10.7	43.7	18.2	0.14	60.2	18.8	0.3	3.2	16.8	0.7	0.0	309

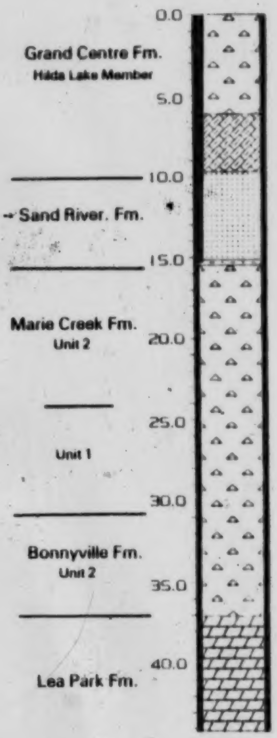
T8



Alberta Geological Survey Testhole T 8
Location of LSD 11 Sec 36 Twp 62 Rng 2 W of 4 Mer NTS 73L
Elevation 1790 Ft 546 M Source 1:50,000 NTS 73L/8
Date drilled 197607 08 Logged by ANDRIASHEK

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00	58.0	11.0	34.0	60.0	12.0	28.0	3.44	13.3				75.7	18.9	1.2	0.0	0.0	4.1	0.0	243
3.00	3.0	39.0	58.0	5.0	46.0	49.0	0.25	21.7				46.6	22.3	2.0	1.9	1.0	26.2	0.0	103
5.00	26.0	30.0	45.0	29.0	32.0	39.0	1.01	13.2				54.0	14.5	1.3	7.9	5.3	17.1	0.0	76
6.00	35.0	29.0	37.0	38.0	30.0	32.0	1.58	11.3				68.3	24.6	0.0	2.4	2.8	2.0	0.0	211
16.00	45.0	28.0	27.0	49.0	28.0	23.0	3.04	9.4				65.8	23.6	0.3	3.1	4.0	3.2	0.0	398
19.50	46.0	26.0	27.0	50.0	27.0	23.0	3.13	9.4				60.2	28.3	0.6	5.5	3.8	1.8	0.0	398
21.00	46.0	26.0	28.0	50.0	26.0	24.0	3.18	9.4				58.5	28.8	0.4	2.6	4.3	2.1	3.1	417
22.00	48.0	27.0	26.0	51.0	28.0	21.0	3.35	9.9				63.1	24.5	0.0	4.6	4.4	3.1	0.2	453
24.00	51.0	34.0	15.0	56.0	31.0	13.0	2.19	10.7				57.0	35.2	0.0	4.2	1.6	2.0	0.0	307
25.00	60.0	20.0	20.0	63.0	20.0	17.0	2.93	7.8				65.9	26.3	0.0	4.3	1.9	1.7	0.0	369
27.00	60.0	24.0	16.0	63.0	23.0	14.0	3.64	8.3				61.1	31.7	0.6	3.2	2.0	1.4	0.0	496
28.00	47.0	27.0	26.0	51.0	28.0	22.0	3.51	8.8				59.8	27.1	0.5	3.6	8.1	0.7	0.0	420
29.00	46.0	28.0	25.0	50.0	30.0	21.0	3.08	9.8				58.8	24.4	0.8	4.9	9.8	0.7	0.0	410

T9

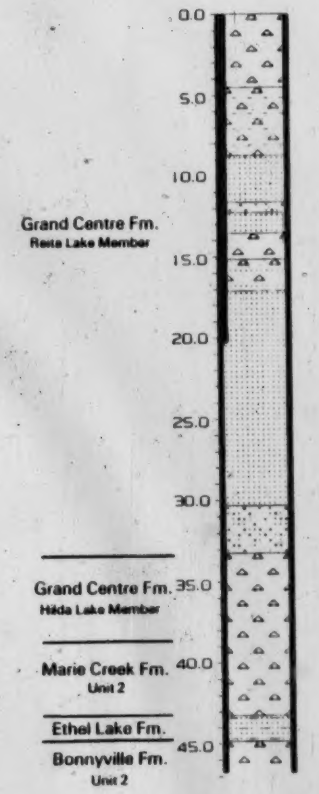


Alberta Geological Survey Testhole T 9
Location SE of LSD 13 Sec 10 Twp 62 Rng 2 W of 4 Mer. NTS 73L
Elevation 1775 Ft 541 M Source 1 50,000 NTS 73L/8
Date drilled 197607 08 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VF SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2 00	9 0	19 0	73 0	10 0	26 0	64 0	0 41	20 0				68 4	21 1	0 0	0 0	0 0	10 6	0 0	57
3 00	26 0	29 0	46 0	29 0	33 0	39 0	1 15	12 6				77 5	15 2	0 7	2 0	3 3	1 3	0 0	151
5 00	28 0	27 0	45 0	32 0	30 0	38 0	1 43	12 6				64 7	29 4	0 5	1 6	2 1	1 6	0 0	187
6 00	4 0	41 0	54 0	5 0	51 0	44 0	0 12	15 2											
8 00	2 0	48 0	50 0	3 0	57 0	41 0	0 21	14 6											
9 00	4 0	34 0	62 0	5 0	45 0	50 0	0 27	15 6											
17 00	40 0	33 0	27 0	45 0	33 0	22 0	3 12	8 9				57 3	18 7	0 3	[illegible]	13 6	4 1	0 0	396
18 00	42 0	31 0	28 0	46 0	32 0	22 0	2 62	8 7				59 2	20 7	1 2	2 7	15 6	6 0	0 0	328
20 00	39 0	33 0	28 0	43 0	34 0	23 0	2 80	8 9				64 9	36 4	0 0	2 7	14 3	1 7	0 0	365
22 00	46 0	26 0	28 0	50 0	28 0	22 0	2 81	9 6				61 1	26 8	0 9	1 5	8 2	1 5	0 0	329
23 00	41 0	26 0	33 0	44 0	29 0	27 0	3 53	9 1				74 4	18 4	0 4	1 5	3 7	1 5	0 0	457
24 00	35 0	31 0	34 0	38 0	35 0	27 0	2 20	9 8				68 3	26 0	0 3	2 0	3 3	0 0	0 0	300
26 00	32 0	34 0	34 0	36 0	37 0	27 0	2 20	9 6				64 0	24 7	1 7	3 1	4 5	2 0	0 0	292
27 00	32 0	33 0	35 0	35 0	36 0	28 0	2 18	9 8				66 2	25 4	0 0	3 8	3 5	1 1	0 0	287
28 00	28 0	32 0	40 0	31 0	38 0	32 0	2 03	11 0				62 5	27 6	0 4	3 9	3 9	1 8	0 0	283
31 00	48 0	29 0	24 0	51 0	31 0	18 0	3 05	9 3				63 4	26 8	0 0	2 3	5 7	1 8	0 0	385
32 00	48 0	29 0	23 0	52 0	31 0	18 0	3 01	8 6				58 4	29 1	1 0	4 8	4 6	1 9	0 0	413
33 00	42 0	28 0	30 0	46 0	30 0	25 0	2 43	8 6				60 8	27 5	1 9	4 9	0 6	4 0	0 0	324
34 00	40 0	30 0	30 0	44 0	31 0	25 0	2 66	10 2				53 0	33 9	2 6	6 6	1 7	2 3	0 0	351
35 00	42 0	27 0	31 0	46 0	29 0	25 0	3 00	8 2				61 3	30 3	2 1	2 6	2 1	1 8	0 0	390
36 00	39 0	30 0	32 0	43 0	31 0	26 0	2 80	10 1				57 8	32 5	0 5	6 1	1 9	1 3	0 0	379
40 00								14 9											
42 00								14 8											
44 00																			

T10

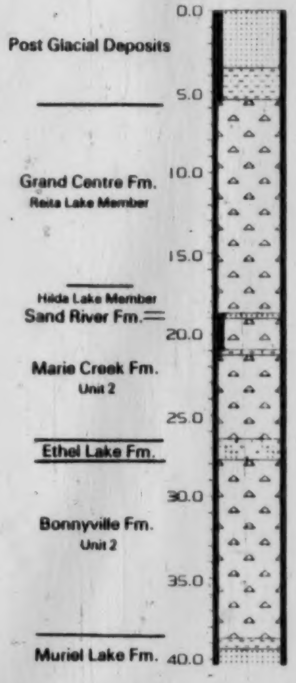
Alberta Geological Survey Testhole - T 10
Location of LSD 9 Sec 16 Twp 63 Rng 4 W of 4 Mer NTS 73L
Elevation 1800 Ft 549 M Source 1 50,000 NTS 73L/7
Date drilled 197607 10 Logged by M FENTON



0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Grand Centre Fm.
Reita Lake Member
Grand Centre Fm.
Hilda Lake Member
Marie Creek Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Unit 2

DEPTH (M)	TEXTURE (%) SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (CC)	CO3 (%)	CA/DO	IGN WT	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LST	DST	LOC	OTH	N
2 00	35 6	40 7	23 7	38 3	44 4	17 4	1 43	8 1				73 8	20 3	0 0	0 6	3 5	1 2	0 6	172
3 00	33 2	42 3	24 5	35 7	43 7	20 7	1 55	9 0				70 1	23 7	1 0	2 1	2 1	1 0	0 0	194
4 00	21 2	57 6	21 2	23 7	59 8	16 5	0 53	11 8				71 8	22 3	2 3	3 5	0 0	0 0	0 0	85
5 00								12 6											
6 00								12 5											
7 00								12 4											
8 00								10 4											
9 00								11 5											
14 00	16 1	64 2	19 7	17 9	67 2	14 9	0 56	14 4				73 7	22 4	2 6	0 0	0 0	1 3	0 0	76
15 00								13 1											
16 00	52 6	38 3	9 1	54 8	38 4	6 8	0 90					74 3	20 5	0 8	0 0	1 7	2 5	0 0	117
31 00												65 6	28 3	1 0	1 9	3 2	0 0	0 0	526
34 00	25 0	46 2	28 7	26 5	51 4	22 1	1 50	12 4				64 6	31 2	0 0	2 6	3 1	3 1	0 5	192
35 00	27 5	44 5	28 0	30 2	47 8	22 0	1 43	11 9				62 5	25 0	0 6	4 2	3 6	4 2	0 0	168
35 50	27 8	44 7	27 5	29 6	49 7	20 8	1 67	12 0				60 1	29 2	0 6	3 9	5 6	0 6	0 0	178
37 00	18 9	47 8	33 4	20 5	53 4	26 1	1 10	14 6				63 9	21 0	0 8	5 0	5 0	4 2	0 0	119
38 00	17 9	46 3	35 7	19 6	53 0	27 4	1 07	17 7				67 5	23 9	0 0	2 6	5 1	0 8	0 0	117
39 00	32 4	42 7	24 9	34 5	46 3	19 2	2 00	13 4				60 0	24 7	0 0	6 4	6 1	2 4	0 0	235
40 00	36 9	40 7	22 4	39 4	43 5	17 1	2 27	11 5				64 0	22 1	0 0	5 2	6 7	1 9	0 0	267
41 00	40 8	39 7	19 5	43 6	42 3	14 1	2 41	11 1				57 0	28 3	0 0	6 1	6 8	1 7	0 0	279
44 00								14 3											
45 00								11 4											
45 50	44 2	40 4	15 5	47 0	41 6	11 4	2 88					67 9	21 7	0 6	3 4	2 8	1 7	0 0	355
46 00	47 5	40 9	11 6	50 6	41 7	7 7	3 49	10 5				70 0	21 1	0 0	4 4	2 2	1 9	0 3	364

T11

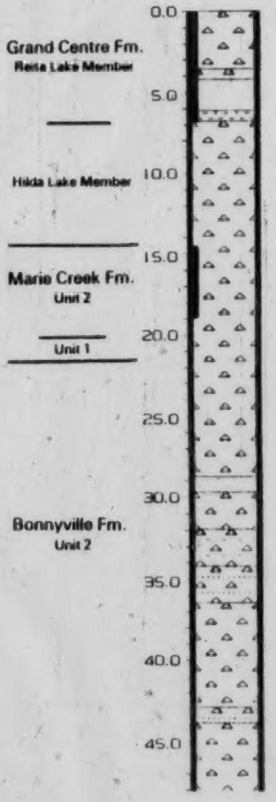


Alberta Geological Survey Testhole T 11
Location of LSD 9 Sec 11 Twp 62 Rng 5 W of 4 Mer NTS 73L
Elevation 1805 Ft 550 M Source 1 50,000 NTS 73L/7
Date drilled 197607 11 Logged by M FENTON

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN MTM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00																			
3.00																			
3.50								26.6											
5.00								26.6											
5.50								24.9											
6.50	40.9	29.5	29.6	45.3	31.9	22.8	1.56	15.8				70.9	23.8	0.0	0.9	2.8	1.5	0.0	210
8.00	29.4	33.6	36.9	35.6	[illegible]	28.2	1.26	16.8				64.0	26.1	0.6	3.1	4.3	1.2	0.6	161
9.00	38.0	27.7	34.3	42.0	31.9	26.2	1.59					69.4	24.3	0.4	1.3	3.1	1.3	0.0	222
10.00	47.0	28.2	24.8	51.9	29.3	18.9	2.25	11.2				71.2	24.2	1.4	0.3	1.8	0.9	0.0	281
11.00	40.5	30.3	29.2	44.3	32.5	23.2	1.46	11.0				65.8	27.3	1.6	1.6	1.6	1.6	0.5	187
12.00								11.5											
13.00	48.5	29.5	22.0	54.0	29.0	17.1	2.03	10.6				69.7	24.9	0.7	1.1	2.5	0.7	0.4	277
14.00	44.5	33.4	22.1	52.3	30.2	17.5	1.55	9.3				72.2	18.2	2.0	2.0	5.5	0.0	0.0	198
15.00	37.9	33.4	28.7	42.6	33.8	23.6	1.15	11.6				72.5	21.6	1.3	3.3	0.0	1.3	0.0	153
16.00	36.4	33.9	29.7	42.0	34.3	23.7	1.14	11.3				72.5	22.2	3.3	0.0	0.6	0.6	0.6	153
17.00	28.4	34.5	37.1	35.7	34.4	30.0	0.80	13.4				75.4	20.2	0.9	1.7	0.9	0.9	0.0	114
18.00	26.5	34.8	38.7	30.4	39.6	30.0	0.54	13.7				72.3	21.7	1.2	2.4	2.4	0.0	0.0	83
19.00	44.5	32.3	23.2	48.7	33.7	17.6	2.85	10.4				65.1	19.3	0.3	3.2	11.1	0.9	0.0	341
20.00	39.7	32.4	27.9	44.4	34.6	21.0	2.43	10.3				60.6	22.9	0.0	3.9	9.8	1.6	0.0	305
21.00	42.0	33.2	24.7	46.7	35.6	17.7	2.19					73.2	16.2	0.4	2.6	6.8	0.4	0.4	265
22.00	42.8	29.9	27.3	46.5	32.9	20.5	2.68	9.9				66.4	23.5	0.3	3.5	4.9	0.9	0.6	345
23.00	52.3	28.1	19.6	56.3	30.1	13.6	3.27	9.4				65.5	29.4	0.0	2.4	1.4	1.2	0.0	412
24.00	44.6	27.6	27.8	47.5	31.3	21.2	3.15	11.2				70.4	21.4	0.3	2.6	3.9	0.8	0.3	379
25.00	42.3	31.5	26.2	46.4	34.1	19.6	2.57	11.6				62.4	27.3	0.8	2.8	5.1	0.3	1.2	351
26.00	44.7	27.1	28.2	47.7	30.9	21.4	3.36	11.9				64.2	28.7	0.0	3.0	1.9	1.8	0.2	428
27.00																			
28.00	52.9	27.4	19.6	56.9	29.4	13.7	3.30	11.2				59.6	29.2	1.1	3.7	2.3	3.6	0.2	431
29.00	52.8	23.4	22.8	57.0	26.1	16.6	2.71	11.6				59.3	33.8	1.6	2.2	1.6	1.4	0.0	364
30.00	52.5	27.6	20.0	56.5	29.6	13.9	2.80	10.[illegible]				64.0	26.6	1.4	4.7	1.6	0.8	0.3	364
31.00	51.6	26.2	22.2	54.8	28.9	16.3	2.91	12.7				64.9	27.9	1.1	2.4	1.9	1.1	0.5	376
32.00	53.1	26.2	20.7	57.1	29.0	13.9	2.83	12.5				58.3	34.9	0.8	3.0	0.8	1.4	0.0	367
33.50	54.5	23.6	21.9	57.5	26.7	15.8	2.74	11.0				56.2	34.0	0.6	3.1	3.6	1.4	0.3	356
34.00	53.0	26.6	20.4	57.0	28.2	14.8	3.47	12.0				58.8	33.0	0.9	3.5	2.8	0.7	0.0	427
35.00	48.4	28.2	23.4	54.7	28.0	17.3	2.81	12.0				58.7	35.7	0.3	2.8	1.4	0.9	0.3	361
36.00	52.8	23.3	23.8	57.0	24.7	18.3	3.05	12.3				68.5	27.3	0.0	1.0	1.5	1.3	0.0	388
37.00	38.9	19.4	41.7	41.6	25.2	33.2	2.22	15.2				57.5	34.2	0.7	3.1	1.7	2.0	0.7	292
38.00	38.7	21.9	39.4	41.7	26.9	31.4	2.84	12.9				64.7	31.3	0.3	1.7	1.7	0.3	0.0	354

T12

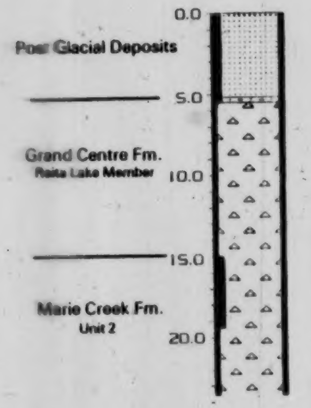
Alberta Geological Survey Testhole 1 12
Location of LSD 4 Sec 4 Twp 62 Rng 4 W of 4 Mer . NTS 73L
Elevation 1830 Ft 558 M Source 1 50,000 NTS 73L/7
Date drilled: 197607 12 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND -62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1 00	37 4	24 0	38 6	41 6	25 7	32 8	1 94	16 1				69 7	24 9	2 1	1 6	1 6	0 0	0 0	241
2 00	39 0	27 9	33 2	44 4	28 6	27 0	1 46	15 4				65 2	30 8	1 5	0 5	1 5	0 5	0 0	201
3 00	36 4	26 4	37 2	40 5	28 4	31 1	1 77	16 8				66 0	26 8	0 9	3 3	2 4	0 5	0 0	209
4 00	40 8	27 2	32 0	45 4	28 5	26 1	1 86	13 9				67 8	26 1	1 3	1 3	2 2	1 3	0 0	230
5 00																			
6 00								15 5											
7 00	31 9	27 7	40 4	36 3	31 0	32 7	0 97	11 2				68 8	24 6	1 6	4 1	0 8	0 0	0 0	122
8 00	20 0	42 1	38 0	33 9	37 2	28 9	0 86	11 9				62 4	29 3	0 9	3 7	2 7	0 9	0 0	109
9 00	33 6	28 7	37 7	38 4	30 8	30 8	1 00	11 6				73 7	22 0	2 8	1 4	0 0	0 0	0 0	141
10 00	28 8	31 9	39 3	35 5	34 6	29 9	0 74	13 2				67 6	29 4	1 0	1 0	1 0	0 0	0 0	102
11 00	34 5	26 5	39 0	39 1	30 4	30 6	1 02	11 5				72 0	24 6	0 0	0 8	2 5	0 8	0 0	119
12 00	32 3	28 5	39 1	36 2	33 7	30 1	0 80	12 9				70 7	25 9	0 9	1 7	0 0	0 8	0 0	116
13 00	29 3	26 2	44 5	33 2	31 7	35 1	0 83					73 7	23 7	0 9	0 9	0 9	0 0	0 0	114
14 00	33 0	31 3	35 6	39 0	33 0	28 0	1 23	11 3				70 7	21 0	1 9	2 5	3 8	0 0	0 0	157
15 00	41 7	31 7	26 6	45 8	33 7	20 5	2 85	9 6				56 6	22 3	0 0	4 8	15 1	1 0	0 0	376
16 00	36 5	38 5	25 0	45 5	35 6	18 9	3 41	8 7				60 4	19 3	0 2	5 7	13 6	0 7	0 0	419
17 00	44 8	31 1	24 2	50 2	31 8	18 0	3 61	9 0				58 3	22 5	0 2	0 4	13 5	1 4	0 0	422
18 00	42 7	30 5	26 8	46 8	32 0	21 2	3 71	8 9				60 3	21 6	0 4	5 2	10 3	2 1	0 0	476
19 00	40 0	29 2	30 8	46 8	26 9	26 3	3 71					64 5	27 8	0 0	1 9	4 1	1 2	0 3	316
20 00	28 0	34 0	38 0	32 1	38 2	29 7	2 36	12 7				62 6	30 9	0 0	2 1	3 4	0 7	0 0	139
21 00	26 8	34 4	38 7	30 5	38 9	30 5	1 23					59 0	32 9	0 0	2 5	3 7	1 8	0 0	161
22 00	52 2	26 6	21 2	56 1	27 3	16 6	3 57	10 9				58 6	31 9	0 4	4 1	2 6	2 0	0 4	464
23 00	52 9	21 5	25 6	55 8	25 3	18 9	2 93	10 1				61 8	31 3	0 0	3 3	1 9	1 3	0 3	367
24 00	49 1	27 0	23 9	53 1	29 1	17 8	2 64	13 5				59 9	30 6	0 0	4 3	2 3	2 3	0 8	349
25 00	47 0	27 6	25 4	50 3	29 8	19 9	2 25	11 0				60 4	32 7	0 3	3 6	1 8	0 6	0 3	278
26 00	46 3	27 7	26 0	49 8	30 6	19 7	2 50	10 5				61 0	32 4	0 3	1 8	2 4	1 8	0 3	336
27 00	44 6	28 0	27 4	48 4	29 8	21 8	2 17	10 8				60 3	33 1	0 0	2 6	2 2	1 8	0 0	272
28 00	47 3	28 8	24 0	52 5	29 9	17 7	2 90	10 9				58 0	34 1	0 0	4 4	2 3	1 2	0 0	343
29 00	62 6	25 3	12 0	67 5	23 3	9 2	3 64	10 2				53 7	32 8	0 6	6 1	1 9	4 8	0 0	475
30 00	58 7	21 9	19 4	62 3	23 6	14 1	3 13	11 7				54 3	36 1	0 2	6 1	1 0	1 7	0 2	390
31 00	45 5	31 1	23 4	49 4	32 2	18 4	2 29	11 4				50 3	41 3	0 0	4 0	2 3	2 0	0 0	298
32 00	22 6	17 0	60 4	24 2	29 5	46 4	1 10					65 7	29 4	0 0	2 0	1 1	0 7	0 0	146
33 50	46 4	27 1	26 5	50 1	29 6	20 3	2 73	13 2				58 6	35 8	0 3	2 5	1 7	1 1	0 0	355
34 00	66 4	15 7	17 9	69 2	17 0	13 7	1 91	14 5				61 1	31 0	0 0	4 6	1 7	1 7	0 0	239
35 00	58 5	20 5	21 0	61 5	20 4	18 0	2 42	13 5				59 5	30 1	0 6	4 6	3 7	1 2	0 3	326
36 00	48 2	30 4	21 4	55 8	26 2	18 0	3 65	11 5				58 3	34 2	0 4	4 0	2 3	0 6	0 0	473
37 00	50 2	28 1	21 6	54 3	27 5	18 2	3 35					53 2	38 3	0 2	3 8	2 0	2 3	0 0	389
38 00	48 5	27 3	24 3	51 9	28 5	19 6	3 14	9 3				59 1	32 4	0 2	2 7	2 5	2 1	0 2	401
39 50	51 7	25 3	23 0	55 1	24 7	20 2	3 41	10 3				54 7	36 2	0 4	4 3	2 0	2 0	0 2	442
40 00	56 9	25 9	17 2	60 8	24 6	14 6	4 06	9 3				62 5	29 9	0 2	3 7	2 1	1 1	0 0	511
41 00	59 9	23 9	16 2	63 1	22 3	14 7	3 38	10 3				58 4	34 2	0 4	2 7	2 0	2 2	0 6	442
42 50	57 7	24 5	17 9	61 3	24 0	14 6	3 60	9 5				58 9	33 0	0 0	3 4	2 3	1 6	0 6	475
43 00	57 2	28 9	13 9	61 3	26 3	12 4	3 21	13 9				63 0	30 3	0 2	4 0	2 1	0 2	0 0	419
44 00	52 3	30 2	17 5	56 6	28 5	14 9	3 33	13 3				61 4	30 6	0 5	3 4	2 7	1 2	0 2	412
46 00	52 8	25 5	21 7	55 8	25 3	18 9	2 78	11 5				66 0	25 6	0 3	3 9	2 3	1 9	0 0	383
47 00	50 3	27 1	22 5	54 2	27 4	18 4	3 24	10 1				62 4	27 4	0 2	4 7	4 0	0 9	0 2	426
48 00	47 9	27 4	24 7	51 7	27 3	21 0	3 52					67 5	24 8	0 6	2 2	3 7	0 8	0 2	455

T13

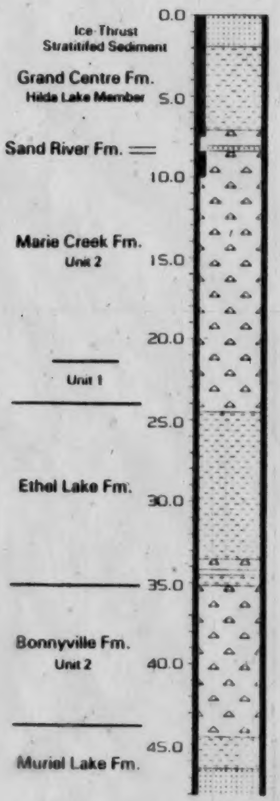
Alberta Geological Survey Testhole 1 13
Location SW of LSD 4 Sec 27 Twp 60 Rng 2 W of 4 Mer . NTS 73L
Elevation 1950 Ft 595 M Source 1 50,000 NTS 73L/1
Date drilled 197607 14 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT OSS	LST	DST	LOC	OTH	N
6 00	20 0	35 0	45 0	25 0	38 0	37 0	0 47	15 8				64 7	30 9	2 9	1 5	0 0	0 0	0 0	68
7 00	39 0	30 0	32 0	43 0	30 0	27 0	1 57	14 0				78 8	13 6	0 5	3 0	4 0	0 5	0 0	198
8 00	40 0	27 0	33 0	44 0	29 0	27 0	1 59	13 6				70 2	22 9	0 5	2 4	3 9	0 0	0 0	205
9 00	36 0	25 0	39 0	40 0	28 0	32 0	1 05	14 2				77 5	16 9	0 6	3 1	1 9	0 0	0 0	160
10 00	36 0	28 0	36 0	40 0	31 0	29 0	0 90	14 7				71 4	20 7	0 0	2 8	5 0	0 0	0 0	140
11 00	39 0	24 0	37 0	43 0	26 0	32 0	1 71	13 5				69 6	24 1	0 1	3 1	2 2	0 4	0 0	224
12 00	38 0	24 0	38 0	42 0	25 0	33 0	1 18	13 6				70 0	23 7	1 2	2 5	2 5	0 0	0 0	160
13 00	39 0	24 0	37 0	43 0	25 0	32 0	1 54	12 9				69 1	24 6	0 8	0 8	4 8	0 0	0 0	126
14 00	31 0	25 0	44 0	34 0	31 0	35 0	1 09	24 3				76 0	20 8	1 9	0 6	0 6	0 0	0 0	154
15 00	41 0	29 0	31 0	44 0	30 0	26 0	2 62	10 5				63 7	21 4	0 6	4 2	9 6	0 6	0 0	355
16 00	35 0	34 0	31 0	39 0	35 0	27 0	2 74	11 7				61 3	18 9	0 3	5 3	12 4	2 1	0 0	339
17 00	38 0	31 0	32 0	42 0	32 0	27 0	2 29	10 7				58 0	18 6	0 3	7 0	13 5	2 6	0 0	312
18 00	37 0	31 0	32 0	41 0	32 0	27 0	3 37	10 8				61 0	17 7	0 5	6 6	13 2	0 8	0 0	362
19 00	38 0	29 0	34 0	41 0	30 0	29 0	2 52	10 6				64 6	15 0	0 0	4 2	15 3	0 9	0 0	333
20 00	38 0	30 0	33 0	42 0	30 0	28 0	2 89	10 7				64 8	20 2	0 3	3 3	10 2	0 8	0 0	361
21 00	38 0	29 0	34 0	41 0	32 0	27 0	2 34	10 0				60 6	20 8	0 9	3 5	13 6	0 6	0 0	317
22 00	37 0	30 0	32 0	41 0	33 0	25 0	2 88	9 9				62 4	20 3	1 4	2 5	9 6	4 1	0 3	364
23 00	38 0	30 0	32 0	41 0	34 0	25 0	2 74	10 6				57 8	24 4	0 0	4 5	14 4	1 4	0 3	353

13B

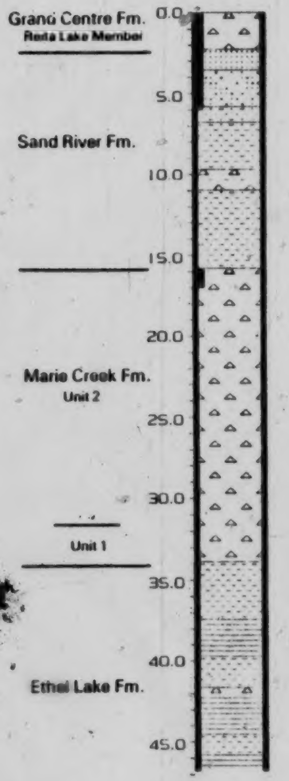
Alberta Geological Survey Testhole 1 13B
Location SE of LSD 1 Sec 30 Twp 60 Rng 2 W of 4 Mer . NTS 73L
Elevation 1875 Ft 572 M Source 1 50,000 NTS 73L/1
Date drilled 197610 22 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00																			
2.00																			
3.00																			
4.00																			
5.00								17.3											
6.00																			
7.00	19.0	33.0	48.0	25.0	34.0	42.0	0.60					66.2	22.1	1.3	6.5	2.6	1.3	0.0	77
8.00	32.0	27.0	40.0	36.0	29.0	36.0	1.60	13.8				62.4	19.6	0.3	3.8	12.5	1.1	0.0	190
9.00	37.0	32.0	31.0	41.0	34.0	25.0	2.80	10.2				67.9	23.2	0.5	4.2	3.7	1.1	0.0	367
10.00	39.0	30.0	31.0	42.0	34.0	25.0	2.50	10.0				64.3	18.5	0.6	3.1	12.0	1.2	0.0	325
11.00	38.0	32.0	31.0	42.0	31.0	24.0	2.90	9.6				60.1	22.8	0.5	4.7	10.1	1.6	0.0	386
12.00	38.0	31.0	31.0	41.0	35.0	24.0	2.60	9.4				60.0	19.7	0.9	3.1	14.2	1.8	0.0	325
13.00	38.0	30.0	32.0	41.0	34.0	25.0	2.60	9.2				59.4	23.9	0.9	4.0	10.7	1.2	0.0	347
14.00	37.0	31.0	33.0	41.0	34.0	26.0	2.90	9.7				62.8	20.6	0.0	4.8	11.3	0.6	0.0	355
15.00	39.0	29.0	32.0	42.0	33.0	25.0	3.00	9.4				68.4	18.4	0.0	3.7	8.5	0.9	0.0	354
16.00	38.0	30.0	32.0	42.0	32.0	26.0	2.40	8.6				61.5	25.5	0.6	2.8	8.0	1.2	0.0	325
17.00	38.0	28.0	34.0	42.0	30.0	28.0	2.60	9.3				60.5	25.9	0.6	3.0	8.7	1.8	0.0	334
18.00	40.0	26.0	34.0	43.0	29.0	28.0	2.70	9.4				61.2	23.2	0.9	3.5	9.9	1.5	0.0	345
19.00	38.0	28.0	34.0	41.0	30.0	29.0	2.20	9.4				66.8	22.2	0.7	2.1	8.0	0.4	0.0	289
20.00	39.0	27.0	34.0	42.0	29.0	29.0	2.60	9.2				63.5	23.5	0.3	3.8	7.9	1.2	0.0	340
21.00	31.0	35.0	34.0	35.0	37.0	28.0	1.90	10.1				65.2	23.5	0.0	4.1	5.3	2.0	0.0	247
22.00	28.0	34.0	38.0	31.0	37.0	31.0	1.30	11.2				64.0	23.3	0.0	4.7	5.8	2.4	0.0	172
23.00	25.0	37.0	38.0	30.0	39.0	31.0	1.00	11.1				57.9	30.3	0.7	4.1	5.5	1.4	0.0	145
24.00	24.0	38.0	38.0	27.0	42.0	32.0	1.00	11.7				66.2	20.0	0.0	5.5	6.2	2.1	0.0	145
25.00	8.0	36.0	56.0	11.0	42.0	47.0	0.20	16.8											
26.00	4.0	42.0	54.0	5.0	51.0	44.0	0.20	17.6											
27.00	10.0	33.0	57.0	11.0	43.0	46.0	0.40	13.1											
28.00	11.0	53.0	36.0	20.0	51.0	29.0	0.20												
29.00	15.0	35.0	50.0	18.0	43.0	40.0	0.30												
30.00	9.0	43.0	48.0	13.0	49.0	38.0	0.10	13.8											
31.00	7.0	41.0	52.0	8.0	50.0	42.0	0.10	14.1											
32.00	5.0	62.0	33.0	9.0	66.0	26.0	0.00	13.5											
33.50	19.0	40.0	42.0	22.0	46.0	32.0	1.00	15.4				66.0	23.4	0.0	5.3	3.4	1.9	0.0	265
34.00	12.0	37.0	51.0	14.0	47.0	40.0	0.50	13.8				60.9	35.0	0.0	2.9	0.0	1.5	0.0	69
35.00	56.0	20.0	24.0	60.0	22.0	19.0	2.90	8.4				61.7	30.1	0.0	3.7	1.6	1.6	0.0	376
36.00	56.0	19.0	25.0	59.0	23.0	19.0	2.80	8.6				64.7	30.8	0.0	2.4	1.6	0.5	0.0	377
37.00	43.0	23.0	35.0	46.0	29.0	25.0	2.20	9.3				58.1	35.2	0.0	1.1	3.0	2.2	0.0	267
38.00	38.0	32.0	30.0	41.0	37.0	23.0	1.80	13.1				59.2	34.5	0.4	3.4	1.7	1.3	0.0	238
39.50	47.0	28.0	25.0	50.0	31.0	20.0	2.40	9.1				65.7	27.2	0.7	2.7	1.0	3.0	0.0	294
40.00	46.0	32.0	22.0	51.0	32.0	17.0	2.20					56.5	33.1	0.0	5.6	2.8	2.1	0.0	287
41.00	44.0	30.0	27.0	47.0	32.0	21.0	2.10	10.5				58.3	31.9	0.4	2.8	2.1	2.5	0.0	283
42.50	42.0	27.0	31.0	46.0	28.0	25.0	2.40	10.1				61.3	29.0	0.3	5.3	2.1	1.2	0.0	341
43.00	56.0	28.0	16.0	60.0	28.0	12.0	3.50	8.9				58.5	32.0	0.7	2.3	2.1	2.0	0.0	434
44.00	11.0	59.0	31.0	12.0	66.0	23.0	0.50												
46.00	17.0	54.0	29.0	19.0	61.0	20.0	0.20												

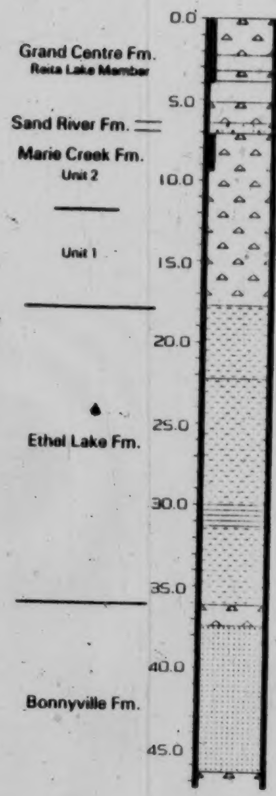
T14

Alberta Geological Survey Testhole I 14
Location SW of LSD 4 Sec 17 Twp 60 Rng 3 W of 4 Mer . NTS 73L
Elevation 1950 Ft 595 M Source 1 50,000 NTS 73L/1
Date drilled 197607 14 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1 00	44 0	22 0	35 0	47 0	21 0	32 0	2 03	12 6				76 5	21 6	1 6	0 0	0 0	0 4	0 0	255
2 00	47 0	23 0	30 0	50 0	24 0	26 0	1 55	11 1				72 3	19 6	1 0	1 4	5 3	0 5	0 0	209
6 00								10 2											
7 00								13 8											
8 00								13 9											
9 50	33 0	28 0	39 0	37 0	31 0	33 0	1 34	9 9				73 9	21 7	1 6	0 0	1 6	1 0	0 0	184
10 00								12 0											
11 00								18 9											
12 00								15 3											
13 00								16 7											
16 00	40 0	36 0	25 0	44 0	35 0	21 0	2 87	7 9				65 0	17 8	0 3	5 2	11 6	0 3	0 0	388
17 00	39 0	35 0	26 0	43 0	36 0	21 0	2 60	9 6				60 6	20 9	0 3	2 7	14 2	1 2	0 0	330
18 00	39 0	36 0	25 0	43 0	36 0	21 0	2 89	9 9				59 4	22 2	0 5	1 6	12 2	4 2	0 0	369
19 00	40 0	36 0	24 0	44 0	36 0	20 0	2 51	9 5				60 3	17 7	0 3	5 1	13 3	3 5	0 0	317
20 00	39 0	35 0	26 0	43 0	36 0	21 0	2 69	9 2				64 8	16 8	0 0	4 6	11 4	2 5	0 0	369
21 00	40 0	34 0	26 0	44 0	35 0	21 0	3 21	9 9				61 1	18 8	0 2	5 1	12 8	1 9	0 0	414
22 00	39 0	34 0	28 0	43 0	35 0	22 0	2 84	9 3				62 3	19 7	0 3	4 3	11 1	2 5	0 0	371
23 00	43 0	31 0	26 0	47 0	33 0	21 0	5 17	9 7				62 2	18 5	0 5	3 2	13 3	2 3	0 0	405
24 00	37 0	35 0	29 0	41 0	35 0	23 0	2 33	7 4				61 3	20 3	0 3	2 8	14 4	0 9	0 0	320
25 00	38 0	33 0	29 0	42 0	36 0	23 0	2 67	8 4				62 8	18 9	0 6	4 5	11 8	1 1	0 0	355
26 00	36 0	33 0	31 0	40 0	36 0	24 0	2 32	8 6				63 9	25 8	1 0	1 3	7 4	0 7	0 0	310
27 00	39 0	31 0	31 0	42 0	33 0	25 0	2 78	10 0				66 1	17 5	0 3	2 8	12 2	1 2	0 0	354
28 00	37 0	33 0	30 0	40 0	36 0	24 0	2 69	9 7				63 8	22 6	0 3	4 1	8 7	0 6	0 0	345
29 00	37 0	32 0	31 0	41 0	37 0	23 0	2 68	9 3				66 9	17 9	1 1	2 8	8 5	2 3	0 3	363
30 00	37 0	32 0	31 0	41 0	36 0	24 0	2 91	9 0				62 5	24 0	0 6	2 8	8 5	1 4	0 3	363
31 00	39 0	32 0	29 0	42 0	36 0	22 0	2 87	10 0				64 8	23 1	0 8	2 4	7 3	1 1	0 3	372
32 00	21 0	41 0	39 0	24 0	45 0	31 0	1 18	11 2				61 0	27 9	0 7	2 6	7 8	0 0	0 0	154
33 50	21 0	41 0	39 0	24 0	45 0	32 0	1 34	41 5				57 6	32 6	0 0	0 6	8 1	0 6	0 0	172
34 00								16 5											
35 00								14 4											
36 00								13 0											
37 00								14 3											
38 00								14 6											
39 50								13 8											
40 00								12 6											
41 00	24 0	37 0	39 0	28 0	42 0	31 0	1 53	10 8				60 1	25 9	0 0	1 0	9 8	3 1	0 0	193
42 50	8 0	44 0	48 0	11 0	51 0	38 0	0 25	13 0											
43 00								13 6											
44 00								15 7											
46 00								17 8											
47 00								17 2											

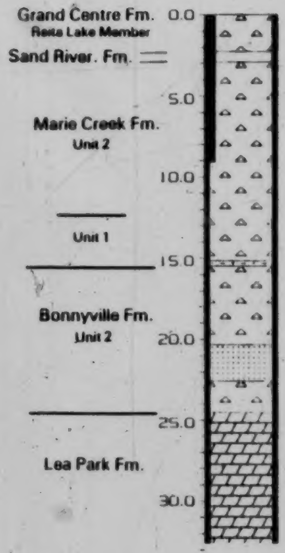
T15



Alberta Geological Survey Testhole T 15
Location NE of LSD 16 Sec 20 Twp 60 Rng 1 W of 4 Mer , NTS 73L
Elevation 1875 Ft 572 M Source 1 50,000 NTS 73L/1
Date drilled 197607 15 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1 00	41 0	25 0	34 0	45 0	27 0	28 0	1 94	10 6				71 1	22 1	1 2	0 1	4 8	0 4	0 0	249
2 00	40 0	24 0	35 0	44 0	26 0	30 0	1 91	11 3				75 8	18 4	1 2	2 3	1 6	0 8	0 0	256
3 00																			
3 50	42 0	25 0	33 0	47 0	25 0	28 0	2 44	17 9				75 8	18 2	1 3	1 6	0 6	2 5	0 0	314
6 00	41 0	26 0	34 0	45 0	27 0	28 0	2 00	14 5				74 8	18 9	0 8	2 4	2 8	0 4	0 0	254
8 00	39 0	34 0	28 0	43 0	35 0	22 0	2 61	11 8				66 7	17 1	0 0	3 8	11 1	1 3	0 0	315
9 00	39 0	33 0	28 0	43 0	34 0	23 0	2 10	10 3				59 9	15 8	0 0	6 5	14 3	2 8	0 0	322
10 00	39 0	35 0	27 0	43 0	36 0	21 0	2 14	10 6				59 1	17 9	1 1	7 4	11 6	2 6	0 0	352
11 00	40 0	33 0	28 0	43 0	35 0	22 0	3 41	9 9				59 5	16 3	0 0	6 2	14 6	3 4	0 0	417
12 00	34 0	32 0	34 0	37 0	36 0	27 0	2 48	9 9				63 8	26 6	0 0	2 8	6 8	0 0	0 0	323
13 00	35 0	32 0	33 0	38 0	36 0	26 0	1 78	10 6				65 5	22 6	0 0	1 8	8 8	0 9	0 0	328
14 00	34 0	34 0	32 0	37 0	38 0	25 0	2 50	10 7				65 3	19 7	0 0	3 1	10 2	1 6	0 0	294
15 00	33 0	33 0	34 0	36 0	38 0	26 0	1 72	11 7				66 0	24 3	0 0	2 1	5 9	0 3	0 0	288
16 00	33 0	33 0	34 0	37 0	36 0	27 0	1 94	10 7				67 3	23 5	0 0	2 3	3 8	2 7	0 4	260
17 00	35 0	32 0	33 0	39 0	36 0	26 0	1 64	9 9				66 4	24 0	0 5	2 3	5 5	1 4	0 0	217
18 00								16 3											
19 00								16 5											
20 00								17 4											
21 00								18 3											
22 00								18 5											
23 00								18 3											
24 00								16 4											
25 00								17 9											
26 00								18 0											
27 00								18 3											
28 00								16 9											
29 00								18 0											
30 00								18 7											
31 00								17 8											
32 00								18 9											
33 50								18 8											
34 00								18 3											
35 00								15 4											
36 00	45 0	28 0	27 0	49 0	32 0	20 0	2 43	11 2				62 6	31 2	0 0	1 2	1 2	3 7	0 0	321
37 00	53 0	32 0	16 0	56 0	32 0	11 0	3 41	11 3				61 5	30 7	0 5	2 5	2 3	2 5	0 0	436
46 00	52 0	31 0	18 0	56 0	31 0	13 0	3 19	10 0				56 0	35 6	0 5	4 1	1 5	1 9	0 5	393

T16

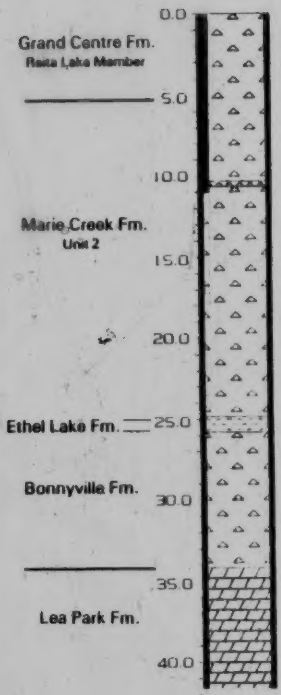


Alberta Geological Survey Testhole T 16
Location SW of LSD 4 Sec 30 Twp 61 Rng 1 W of 4 Mer NTS 73L
Elevation 1780 Ft 543 M Source 1 50,000 NTS 73L/8
Date drilled 197607 16 Logged by ANDRIASHEK

DEPTH (M)	TEXTURE (%) SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN MITM	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1 00	42 5	25 7	31 8	46 7	26 4	27 0	1 83												
2 00	44 0	27 8	28 2	48 0	28 4	23 6	2 22	8 9				72 3	21 0	0 9	1 9	3 3	0 5	0 0	577
3 00																			
4 00	51 3	27 9	20 8	55 0	28 0	17 0	3 32	8 7				63 4	19 3	0 7	5 4	9 2	1 9	0 0	571
5 00	40 3	33 2	26 5	44 6	33 5	21 9	3 00	9 9				62 3	21 5	0 2	2 4	9 5	2 4	0 0	422
6 00	40 5	30 3	29 2	44 2	31 9	23 9	2 59	10 1				66 3	18 5	1 1	3 5	9 5	1 1	0 0	655
7 00	42 0	31 2	26 7	46 5	32 0	21 5	2 85	9 6				65 2	21 3	0 5	3 9	7 6	1 4	0 0	592
8 00	46 7	28 5	24 8	50 5	29 6	19 9	2 85	9 9				64 0	24 9	0 0	3 1	7 9	0 0	0 0	417
9 00	37 3	32 8	29 8	42 1	34 5	23 4	2 96	10 4				72 4	17 1	0 2	2 4	6 8	0 9	0 0	457
10 00	36 7	31 1	32 2	39 9	34 8	25 4	2 62	10 5				67 9	18 1	0 2	4 7	7 4	1 5	0 0	580
11 00	37 5	30 3	32 2	41 7	32 9	25 4	3 59	9 9				70 6	16 2	0 2	3 1	8 0	1 7	0 0	687
12 00	36 8	31 5	31 7	39 9	35 2	24 9	2 98	11 7				69 9	20 3	0 0	4 0	3 1	2 3	0 0	479
13 00	28 3	36 6	35 2	31 7	40 6	27 7	2 04	12 6				59 6	28 1	0 3	2 8	6 1	3 1	0 0	359
14 00	29 8	34 1	36 0	32 4	39 4	28 2	1 92	12 9				62 3	24 4	0 5	3 6	5 7	3 1	0 0	385
15 00								13 2											
16 00	41 3	35 4	23 4	45 6	36 7	17 7	2 55	9 4				62 0	26 7	0 4	3 4	5 1	2 1	0 0	468
17 00	45 7	32 4	21 8	49 4	34 0	16 6	2 79	8 9				57 6	29 1	0 2	3 7	6 2	2 5	0 0	484
18 00	54 5	24 4	21 1	59 1	25 1	15 8	3 35	8 7				55 0	36 9	0 0	3 8	1 6	2 2	0 0	705
19 00	54 2	23 1	22 7	57 3	25 7	17 0	2 85	9 6				56 6	32 8	0 0	3 7	4 2	2 4	0 0	378
20 00	51 0	25 9	23 1	54 9	28 1	17 0	2 85	11 4				59 5	31 9	0 3	3 1	3 1	1 7	0 0	351
23 00	40 7	34 8	24 5	45 0	37 1	17 9	2 81	10 6				46 3	44 5	0 8	3 5	2 8	2 0	0 0	508
24 00								15 1											
25 00								18 4											
26 00								19 2											
27 00								15 5											
28 00								16 7											
29 00								15 4											
30 00								15 2											
31 00								21 8											
32 00								18 9											

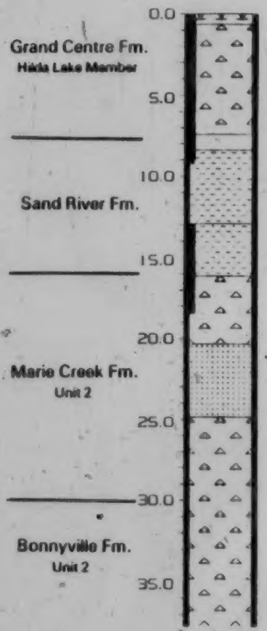
T17

Alberta Geological Survey Testhole T 17
Location NE of LSD 7 Sec 36 Twp 61 Rng 3 W of 4 Mer . NTS 73L
Elevation: 1800 Ft 549 M Source 1 50,000 NTS 73L/8
Date drilled 197607 17 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)					
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	40.0	23.0	37.0	43.0	23.0	34.0	2.10	12.8				68.3	25.8	1.9	2.2	1.9	0.0	0.0	271
2.00	41.0	23.0	36.0	44.0	25.0	32.0	1.90	10.8				73.2	21.1	1.9	1.5	2.3	0.0	0.0	261
3.00	36.0	29.0	35.0	40.0	30.0	30.0	1.40	11.7				68.6	24.6	1.0	2.6	2.1	0.5	0.5	191
4.00	44.0	26.0	30.0	47.0	26.0	27.0	1.80	11.1				67.1	24.3	0.8	2.1	4.9	0.8	0.0	243
5.00	47.0	24.0	29.0	52.0	22.0	26.0	1.60	10.9				74.1	19.0	1.4	2.3	1.9	1.9	0.0	216
6.00	42.0	33.0	25.0	45.0	34.0	21.0	2.90	8.5				64.0	15.6	1.1	4.5	13.1	1.6	0.0	358
7.00	44.0	34.0	22.0	48.0	34.0	18.0	3.50	7.6				61.9	22.1	0.2	2.8	12.3	0.7	0.0	430
8.00	45.0	32.0	23.0	49.0	32.0	20.0	3.20	8.5				60.9	20.0	0.3	4.5	13.2	1.3	0.0	401
9.00	43.0	29.0	28.0	47.0	29.0	24.0	2.50	9.8				64.1	23.5	1.2	2.5	7.3	1.5	0.0	354
10.00	44.0	24.0	33.0	47.0	27.0	26.0	2.90	9.3				63.3	22.2	0.6	2.0	10.3	1.8	0.0	351
11.00	50.0	22.0	28.0	53.0	23.0	24.0	2.90	9.9				70.1	22.4	0.5	2.9	2.9	1.3	0.0	375
12.00	47.0	23.0	30.0	50.0	23.0	26.0	2.90	10.4				65.7	24.5	0.0	2.2	3.5	4.1	0.0	367
13.00	42.0	25.0	34.0	44.0	28.0	28.0	2.50	10.7				60.7	30.1	0.3	4.3	2.2	2.5	0.0	326
14.00	50.0	21.0	29.0	54.0	22.0	25.0	2.50	9.6				64.4	29.0	0.3	3.6	2.1	0.6	0.0	331
15.00	50.0	20.0	30.0	53.0	21.0	25.0	2.60	9.9				57.4	32.3	0.9	2.3	1.7	0.6	4.9	350
16.00	47.0	22.0	31.0	51.0	23.0	26.0	2.70	9.2				62.0	22.9	0.6	4.5	2.0	1.4	6.7	358
17.00	42.0	23.0	35.0	44.0	26.0	30.0	2.50	10.5				61.7	20.5	0.3	4.0	0.6	1.4	11.7	352
18.00	49.0	21.0	30.0	51.0	23.0	25.0	2.50	9.5				61.7	29.1	1.0	3.5	2.2	2.3	0.3	316
19.00	50.0	20.0	30.0	54.0	21.0	25.0	2.80	9.7				68.8	25.3	0.0	3.2	1.6	1.1	0.0	372
20.00	50.0	22.0	28.0	54.0	24.0	23.0	3.10	9.2				71.6	21.1	0.3	0.3	0.3	1.1	5.4	355
21.00	50.0	20.0	29.0	54.0	21.0	26.0	2.40	9.0				64.0	28.0	0.0	3.7	2.2	2.5	0.0	325
22.00	53.0	19.0	28.0	56.0	20.0	24.0	2.60	9.2				60.9	25.7	0.6	3.7	3.4	2.0	3.7	350
23.00	50.0	21.0	28.0	54.0	22.0	24.0	2.60	9.4				54.7	32.5	0.6	2.7	3.0	1.5	5.3	338
24.00	46.0	24.0	30.0	49.0	27.0	24.0	2.30	15.1				62.0	32.9	0.3	2.5	4.1	1.3	0.0	316
25.00	16.0	25.0	59.0	17.0	37.0	46.0	0.50	13.0				47.6	40.5	1.2	1.2	3.6	6.0	0.0	84
26.00	37.0	25.0	38.0	39.0	30.0	30.0	2.10	10.3				53.6	38.0	2.4	1.6	1.2	2.4	0.8	250
27.00	37.0	25.0	39.0	40.0	30.0	30.0	2.40	10.9				53.8	38.3	0.3	3.7	3.0	0.6	0.3	329
28.00	40.0	23.0	37.0	42.0	28.0	29.0	2.30	10.0				57.8	35.2	1.0	3.7	2.3	0.0	0.3	301
29.00	46.0	24.0	30.0	50.0	27.0	23.0	2.50	7.9				64.2	30.8	1.7	1.7	0.8	0.8	0.0	357
30.00	46.0	24.0	30.0	50.0	27.0	23.0	3.00	12.7				52.7	41.3	1.7	2.0	1.2	1.1	0.0	404
31.00	49.0	24.0	28.0	51.0	27.0	22.0	3.20	9.3				55.5	40.5	0.8	2.0	0.8	0.6	0.0	400
32.00	49.0	23.0	28.0	52.0	26.0	22.0	3.20	7.1				56.7	32.1	0.0	4.6	3.1	3.6	0.0	416
33.50	30.0	38.0	32.0	35.0	40.0	26.0	1.10	10.1				46.8	43.3	2.8	1.4	3.5	1.4	0.0	143
34.00	1.0	28.0	72.0	1.0	39.0	60.0	0.00	13.6											
35.00	1.0	34.0	65.0	1.0	45.0	54.0	0.00	18.4											
36.00	1.0	35.0	65.0	2.0	45.0	54.0	0.00	17.4											
37.00	5.0	37.0	58.0	7.0	44.0	49.0	0.00	18.5											
38.00	2.0	34.0	65.0	2.0	44.0	54.0	0.10	17.8											
39.50	1.0	31.0	67.0	3.0	41.0	56.0	0.00	13.5											
40.00	3.0	32.0	66.0	4.0	42.0	54.0	0.00	17.9											
41.00	2.0	33.0	65.0	4.0	42.0	54.0	0.00	14.5											

T18



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Alberta Geological Survey Testhole    T  18
Location   NE of LSD  9 Sec 18 Twp  61 Rng  3 W of 4 Mer .   NTS  73I
Elevation   1825 Ft      556 M   Source  1 50,000 NTS 73L/8
Date drilled:    197607 18  Logged by  ANDRIASHEK

                       TEXTURE (%)                         MATRIX CARBONATE         COARSE SAND LITHOLOGY (%)
 DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H2O    CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
  (M) >62 5um     <4um  >50um      <2um 1 2mm  (%)    (cc)  (%)        METM        QSS

  1 00  32 0 25 0 43 0  36 0 28 0 37 0  1 60  13 2                     70 7  22 4  1 0  3 9  2 4  0 5  0 0   205
  2 00  33 0 24 0 43 0  37 0 27 0 36 0  1 40  13 9                     74 7  21 4  0 6  1 1  1 7  0 6  0 0   182
  3 00  34 0 25 0 41 0  37 0 28 0 35 0  1 78  14 7                     73 3  24 0  0 9  0 9  1 3  0 0  0 0   225
  4 00  34 0 26 0 40 0  37 0 30 0 34 0  1 73  15 3                     70 6  23 4  1 7  1 7  2 6  0 0  0 0   235
  5 00  32 0 26 0 42 0  36 0 30 0 35 0  1 40  14 7                     73 3  21 4  1 6  1 1  0 5  2 2  0 0   187
  6 00  37 0 26 0 37 0  42 0 28 0 31 0  1 78  13 2                     75 7  18 5  0 9  1 4  2 7  0 9  0 0   222
  7 00  41 0 26 0 33 0  45 0 28 0 27 0  1 94  12 1                     72 4  20 5  0 4  2 0  3 9  1 2  0 0   254

  9 00                                        17 2
 10 00                                         9 8
 11 00                                        26 6
 12 00                                        16 5
 13 00  20 0 48 0 32 0  22 0 55 0 23 0  1 54  14 4                     56 9  23 1  0 5  3 1 14 9  1 0  0 0   195
 14 00  13 0 55 0 32 0  15 0 63 0 22 0  0 70  16 4                     74 7  14 7  0 0  6 7  2 7  1 3  0 0    75
 15 00                                        15 6
 16 00  43 0 35 0 23 0  47 0 35 0 18 0  3 06   9 [illegible]            61 2  17 7  0 3  3 3 16 1  1 4  0 0   361
 17 00  43 0 34 0 24 0  46 0 35 0 19 0  3 77   8 1                     64 3  15 0  0 5  4 2 15 4  1 4  0 0   448
 18 00  43 0 31 0 25 0  47 0 33 0 20 0  3 27   9 6                     62 4  16 4  0 7  3 8 15 0  1 6  0 0   420
 19 00  46 0 31 0 24 0  49 0 32 0 19 0  2 18   9 4                     65 0  13 7  1 3  4 1 12 7  2 8  0 0   314
 20 00  40 0 32 0 28 0  44 0 33 0 23 0  2 89   7 8                     65 6  18 0  0 8  3 8 11 0  0 6  0 0   372


 24 50  39 0 32 0 29 0  43 0 33 0 24 0  2 51   8 9                     68 4  20 5  0 6  1 5  9 0  0 6  0 0   332
 25 00  44 0 25 0 30 0  47 0 27 0 26 0  2 88   8 3                     72 8  21 1  0 0  1 7  4 2  1 1  0 0   356
 26 00  47 0 25 0 29 0  50 0 26 0 23 0  2 59   8 1                     70 8  23 1  0 0  3 2  1 8  1 5  0 0   342
 27 00  42 0 33 0 25 0  46 0 33 0 21 0  2 66   7 7                     67 6  22 1  0 0  1 8  8 3  0 6  0 0   339
 28 00  39 0 31 0 30 0  43 0 32 0 25 0  2 55   9 0                     67 5  20 1  0 3  2 1  8 6  1 8  0 0   338
 29 00  35 0 27 0 38 0  38 0 30 0 32 0  2 69   8 9                     68 5  20 5  0 3  1 7  7 8  1 4  0 0   352
 30 00  44 0 28 0 28 0  47 0 29 0 24 0  2 44   8 9                     60 9  31 4  1 0  4 2  1 0  1 0  0 6   312
 31 00  46 0 28 0 27 0  49 0 29 0 23 0  2 30   9 1                     57 7  33 5  0 0  4 1  2 5  2 2  0 0   319
 32 00  45 0 39 0 16 0  49 0 37 0 13 0  3 39   9 3                     57 3  35 3  0 2  3 6  2 2  1 3  0 0   450

 33 50  49 0 29 0 22 0  53 0 27 0 20 0  2 18  10 7                     67 4  28 3  0 0  3 2  1 1  0 4  0 4   279

 35 00  50 0 24 0 25 0  54 0 24 0 22 0  2 52  10 7                     63 0  29 4  1 8  3 9  1 8  0 6  0 0   330
 36 00  53 0 22 0 25 0  56 0 22 0 22 0  3 16   9 8                     64 2  29 8  0 7  1 6  4 2  0 2  0 0   430
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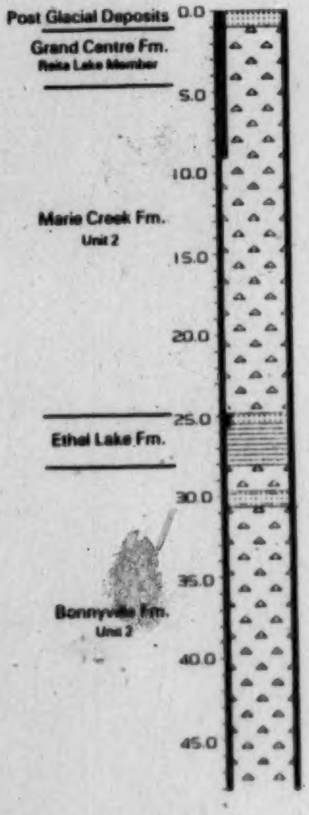
T19

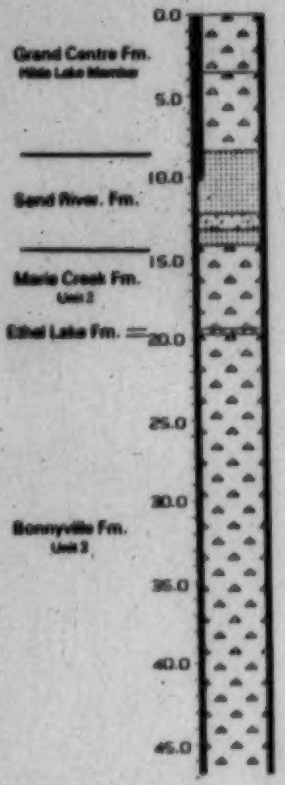
Alberta Geological Survey Testhole T 19
Location SW of LSD 16 Sec 30 Twp 64 Rng 2 W of 4 Mer . NTS 73L
Elevation 1875 Ft 572 M Source 1 50,000 NTS 73L/8
Date drilled 197608 07 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METH	COARSE SAND LITHOLOGY (%) QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00																			
2.00	41.0	25.0	34.0	45.0	27.0	29.0	1.63	13.9				70.2	24.0	0.9	0.0	0.0	4.9	0.0	225
3.00	39.0	27.0	35.0	43.0	29.0	28.0	1.45	15.9				70.4	25.2	0.0	0.5	2.4	0.5	0.0	206
4.00	35.0	25.0	41.0	39.0	28.0	34.0	1.45	16.9				66.0	28.1	1.6	0.0	3.2	0.5	0.0	185
5.00	43.0	31.0	27.0	47.0	32.0	21.0	3.31	12.9				58.5	20.8	0.2	4.3	14.6	1.7	0.0	419
6.00	41.0	31.0	28.0	45.0	32.0	23.0	2.60	11.4				56.7	22.5	0.8	3.9	13.2	2.8	0.0	356
7.00	49.0	27.0	24.0	53.0	27.0	20.0	3.31	9.6				61.1	27.7	0.2	4.1	4.5	2.4	0.0	419
8.00	50.0	27.0	23.0	54.0	28.0	18.0	3.63	9.9				59.3	28.6	0.7	6.4	3.1	1.8	0.2	455
9.00	51.0	27.0	22.0	55.0	29.0	16.0	3.37	10.0				63.7	25.6	0.5	4.7	4.0	1.6	0.0	430
10.00	51.0	28.0	21.0	55.0	30.0	15.0	3.29	10.2				56.9	31.9	0.3	4.2	4.7	2.0	0.0	404
11.00	49.0	29.0	22.0	53.0	31.0	16.0	3.43	9.8				58.0	30.3	0.5	3.4	5.8	1.8	0.2	445
12.00	58.0	25.0	17.0	62.0	26.0	12.0	3.17	10.0				58.1	30.3	0.5	5.0	4.3	1.6	0.0	442
13.00	46.0	29.0	24.0	49.0	33.0	17.0	3.47	10.4				70.0	24.9	0.0	0.7	3.7	0.4	0.2	437
14.00	46.0	29.0	26.0	49.0	33.0	18.0	3.15	10.5				58.6	27.0	0.5	5.1	5.6	3.1	0.3	396
15.00	46.0	29.0	26.0	50.0	30.0	20.0	2.66	9.9				64.7	28.1	0.5	2.4	3.6	1.2	0.0	416
16.00	47.0	27.0	26.0	51.0	29.0	21.0	3.86	10.6				64.5	26.0	0.4	2.9	3.3	2.6	0.4	273
17.00	46.0	27.0	27.0	50.0	28.0	22.0	2.06					64.9	27.1	0.4	2.0	3.3	2.4	0.0	458
18.00	48.0	29.0	23.0	51.0	30.0	19.0	3.55					73.0	21.9	0.4	2.6	1.7	0.2	0.2	466
19.00	48.0	27.0	25.0	52.0	28.0	20.0	4.11					73.3	22.7	0.2	1.4	1.6	0.8	0.0	506
20.00	48.0	25.0	27.0	51.0	27.0	22.0	3.98					70.6	24.5	0.2	1.9	1.9	1.2	0.0	531
23.00	46.0	28.0	26.0	50.0	29.0	21.0	3.00					67.6	27.3	0.3	1.9	2.4	0.6	0.0	370
24.00	47.0	26.0	27.0	51.0	27.0	22.0	3.42					71.8	22.2	0.0	3.7	1.2	1.1	0.0	432
28.00	51.0	28.0	21.0	55.0	29.0	16.0	3.16					51.6	41.6	1.7	1.7	2.2	0.2	0.9	411
29.00	48.0	29.0	24.0	51.0	31.0	18.0	3.30					47.7	44.8	0.2	4.3	2.5	0.4	0.0	438
30.50	49.0	28.0	24.0	52.0	28.0	19.0	2.89					51.3	39.7	0.8	3.5	1.6	2.8	0.2	491
31.00	46.0	29.0	26.0	49.0	32.0	19.0	2.80					49.1	44.9	1.0	2.1	1.0	1.1	0.8	383
32.00	45.0	30.0	25.0	49.0	32.0	19.0	3.09					51.0	43.5	0.5	1.2	1.5	2.1	0.2	414
33.00	47.0	29.0	25.0	51.0	31.0	19.0	2.57					49.2	44.9	1.7	1.1	2.0	0.9	0.3	352
34.00	46.0	29.0	24.0	50.0	32.0	18.0	3.07					52.1	40.3	2.4	1.7	1.0	1.9	0.5	409
35.00	45.0	31.0	24.0	49.0	32.0	19.0	3.39					50.0	40.6	1.6	4.3	1.8	1.5	0.0	438
36.00	48.0	28.0	23.0	52.0	30.0	18.0	3.08					51.5	44.4	0.9	1.6	0.9	0.7	0.0	437
37.00	51.0	23.0	26.0	55.0	25.0	21.0	3.02					56.8	37.6	0.5	2.1	1.2	1.7	0.2	426
38.00	47.0	28.0	25.0	51.0	30.0	20.0	2.77					51.8	42.8	1.3	1.6	1.8	0.6	0.3	388
39.00	45.0	29.0	26.0	49.0	32.0	19.0	2.84					52.1	40.9	1.1	1.9	0.5	2.2	1.3	374
40.00	49.0	27.0	24.0	53.0	29.0	19.0	2.39					45.0	46.2	0.7	1.9	1.2	5.1	0.0	416
42.00	46.0	31.0	24.0	49.0	32.0	19.0	2.76					56.6	39.2	0.8	1.4	0.8	0.8	0.3	362
43.00	49.0	29.0	22.0	53.0	30.0	17.0	3.15					57.2	36.1	1.5	2.4	1.2	1.5	0.0	407
44.00	51.0	28.0	22.0	54.0	29.0	17.0	3.13					49.5	42.7	2.1	0.9	1.4	3.0	0.2	426
46.00	52.0	27.0	21.0	55.0	28.0	17.0	3.14					62.6	33.2	0.9	1.1	0.7	1.4	0.0	419
47.00	52.0	28.0	20.0	56.0	28.0	16.0	3.43					55.6	38.1	0.8	1.6	1.0	2.2	0.6	491
48.00	52.0	29.0	20.0	56.0	29.0	15.0	2.89					49.3	43.5	1.0	3.5	1.0	1.1	0.8	398

T20

Alberta Geological Survey testhole   T 20
Location: of LSD 1 Sec 26 Twp 64 Rng 5 W.of 4 Mer . NTS 73L
Elevation: 1985 Ft.   605 M Source 1:50,000 NTS 73L/10
Date drilled: 197607.20 Logged by: M. FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								14.1											
2.00	24.1	26.4	49.5	27.0	28.1	44.9	0.88	14.7				65.6	32.1	2.3	0.0	0.0	0.0	0.0	131
3.00	24.3	20.6	55.1	27.1	25.4	47.5	0.97	17.3				73.5	23.6	1.4	0.0	0.0	1.4	0.0	140
4.00	24.4	24.5	51.1	27.0	30.3	42.7	0.87	16.4				73.2	22.3	0.0	1.8	1.8	0.0	1.8	112
5.00								18.9											
6.00								12.6											
7.00								20.8											
8.00								12.6											
15.00	49.6	27.2	23.2	54.9	26.4	18.7	2.87					56.3	31.4	0.0	3.7	6.4	2.2	0.0	373
16.00	51.7	27.3	21.0	55.7	27.7	16.7	2.91					62.8	26.7	0.0	4.1	5.3	1.0	0.0	393
17.00	49.3	29.0	21.7	54.4	28.1	17.5	2.96	10.3				58.6	28.0	0.9	3.8	6.7	2.0	0.0	343
18.00	49.7	27.1	23.3	53.4	29.7	16.9	2.89	9.4				59.9	31.6	0.6	3.3	3.3	1.4	0.0	364
19.00	47.6	27.6	24.8	52.7	29.6	17.7	2.57	9.9				61.6	30.6	0.6	3.4	2.6	0.6	0.3	349
20.00	41.7	28.8	29.5	45.1	33.9	21.0	2.73	10.6				64.9	28.7	0.0	2.8	3.1	0.6	0.0	350
21.00	44.3	26.1	29.7	48.7	29.6	21.7	2.60					62.2	31.3	0.0	4.9	1.3	0.3	0.0	370
22.00	45.5	25.9	28.6	48.8	30.7	20.5	3.00	10.4				67.3	27.5	0.0	0.8	2.9	1.1	0.3	382
23.00	44.4	25.4	30.3	48.7	28.2	23.1	2.49	10.3				63.4	32.0	0.0	3.8	0.6	0.3	0.0	344
24.00	44.3	26.8	28.9	48.4	29.8	21.8	2.52	9.2				67.0	28.9	0.0	1.7	1.7	0.6	0.0	349
25.00	48.3	22.1	29.7	51.5	25.0	23.5	2.20	9.6				57.0	34.7	0.0	4.0	2.3	1.6	0.0	300
26.00	44.7	26.0	29.3	48.7	28.6	22.6	2.79	10.0				65.6	29.2	0.0	2.2	1.9	1.1	0.0	363
27.00	46.4	25.2	28.4	49.5	27.9	22.6	2.94	9.7				68.6	26.6	0.0	2.6	1.6	0.6	0.0	379
28.00	44.6	26.2	29.1	48.6	28.8	22.6	2.73	11.0				67.0	27.2	0.0	3.4	1.3	1.0	0.0	379
29.00	44.3	23.6	32.1	47.4	27.5	25.1	2.62	9.8				61.9	31.0	0.3	3.5	2.3	0.9	0.3	339
30.00	44.9	24.0	31.1	48.9	27.4	23.8	2.70	9.8				68.1	27.4	0.3	1.4	2.2	0.3	0.3	397
31.00	45.9	24.1	29.9	49.1	27.2	23.8	2.81	9.6				64.6	28.9	0.0	2.6	2.3	1.2	0.3	342
32.00	45.0	25.2	29.8	49.1	27.7	23.2	3.01	8.0				68.4	27.4	0.5	1.7	1.5	0.4	0.0	402
33.90	46.0	23.5	30.5	49.0	26.8	24.2	2.63	8.8				62.7	33.2	0.0	2.2	0.8	0.8	0.3	370
34.00	44.6	25.4	30.0	48.5	28.5	22.9	2.90	8.5				63.3	31.0	0.3	1.5	3.1	0.6	0.0	387
35.00	45.6	23.9	30.5	48.8	27.2	24.1	2.79					67.0	28.4	0.3	2.3	1.1	0.9	0.0	352
36.00	45.1	25.8	29.0	49.3	27.0	23.7	2.98	8.7				66.5	30.0	0.0	0.8	1.3	1.3	0.0	373
37.00	45.2	23.4	31.3	48.9	26.1	25.0	2.83	9.0				68.4	25.1	0.5	3.2	1.6	0.8	0.0	370
38.00	44.8	24.0	31.2	49.0	27.3	23.7	2.61	9.4				61.8	33.6	0.3	1.5	1.9	0.6	0.3	327
39.90	45.9	23.5	30.6	49.2	26.3	24.4	3.02	9.3				63.5	30.2	0.3	1.8	2.4	1.6	0.0	381
40.00	44.4	24.9	30.7	48.8	27.0	24.1	3.04	9.1				64.9	28.5	0.2	4.1	1.5	0.5	0.0	393
41.00	45.0	22.6	32.3	48.3	26.5	25.2	2.81	8.8				70.2	24.2	0.5	3.6	0.8	0.5	0.0	363
42.90	44.3	24.7	30.9	48.5	26.7	24.9	2.93	9.2				66.5	28.8	0.2	1.2	1.5	1.6	0.0	406
43.00	45.6	22.8	31.6	48.9	25.2	25.8	3.03					66.2	28.3	0.2	2.2	2.0	1.0	0.0	406
44.00	44.8	24.5	30.8	49.2	27.2	23.6	2.83	9.1				71.1	25.5	0.0	1.3	1.3	0.4	0.3	388
45.00	46.5	23.3	30.1	49.9	25.7	24.4	3.30	9.4				65.1	29.4	0.0	2.6	1.7	0.9	0.0	415
47.00	44.5	24.0	31.6	48.7	27.0	24.4	3.15	9.0				66.4	29.8	0.0	1.2	1.7	0.6	0.0	402

T21

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Alberta Geological Survey Testhole   1  21
Location:     of LSD  4 Sec 13 Twp  64 Rng  5 W of 4 Mer.,  NTS: 73L
Elevation:  1825 Ft     556 M  Source: 1:50,000 NTS 73L/10
Date drilled:   197607.26  Logged by: M. FENTON

                   TEXTURE (%)                          MATRIX CARBONATE        COARSE SAND LITHOLOGY (%)
 DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H2O    CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
  (M) >62.5um    <4um  >50um     <2um 1-2mm   (%)   (cc)  (%)          METM   + OSS
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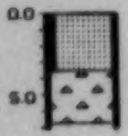
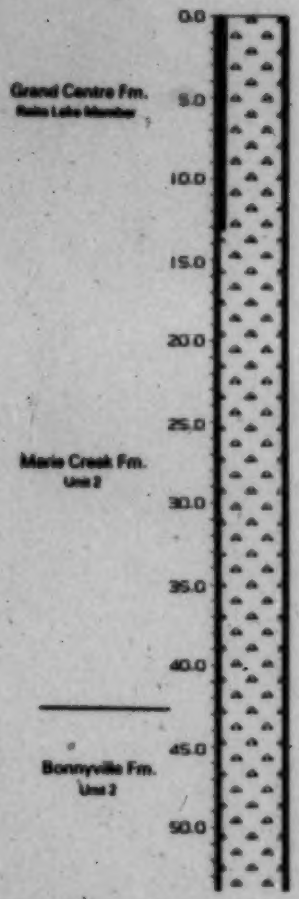


T22

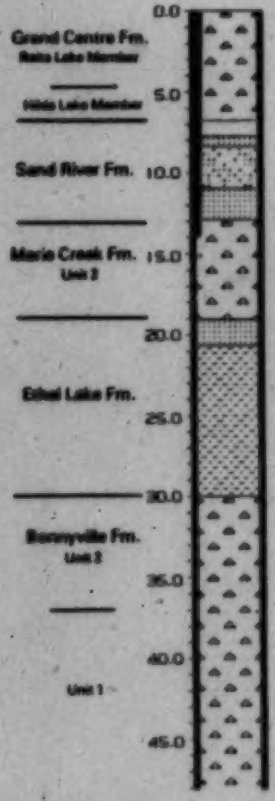
Alberta Geological Survey Testhole 1 22
Location: of LSD 7 Sec 19 Twp 65 Rng 5 W of 4 Mer . NTS 73L
Elevation: 2125 Ft 648 M Source: 1 50,000 NTS 73L/10
Date drilled: 197607 27 Logged by M FENTON



DEPTH	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
(M)	SAND >62.5um	SILT	CLAY <4um	SAND >90um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	41.2	23.6	35.1	45.5	25.3	29.2	1.50	13.9				72.1	21.9	3.0	0.0	0.5	2.0	0.5	201
2.00	40.6	28.7	30.7	44.9	30.4	24.7	1.66	12.4				62.4	26.8	3.0	2.0	5.4	0.5	0.0	205
3.00	38.2	29.1	32.7	43.0	29.8	27.3	1.61	13.2				68.7	24.0	1.7	1.7	3.4	0.6	0.0	179
4.00	40.6	29.0	30.4	45.3	30.3	24.4	1.44	11.9				70.0	20.4	3.2	3.8	2.2	0.5	0.0	186
5.00	49.8	18.0	32.2	51.2	21.9	26.9	2.11	12.7				70.6	20.6	1.3	1.7	5.0	0.4	0.4	238
6.00	38.8	28.8	33.4	42.8	30.7	26.5	1.65	12.8				74.8	18.3	0.5	2.0	4.5	0.0	0.0	202
7.00	39.5	26.2	34.3	43.4	28.7	27.9	2.50	12.8				71.9	20.2	0.3	0.9	6.1	0.0	0.6	327
8.00	45.8	26.7	27.5	49.9	28.2	21.9	3.87	10.0				78.3	16.6	0.8	0.6	3.4	0.2	0.0	494
9.00	39.9	26.6	33.5	44.3	29.1	27.6	2.80	10.4				71.5	20.8	0.8	2.2	3.6	1.1	0.0	361
10.00	44.2	25.7	30.0	48.1	28.2	23.6	3.28	10.3				81.8	14.0	0.2	1.0	1.5	1.5	0.0	406
11.00	45.3	24.8	29.9	48.6	25.5	25.0	3.56	9.5				73.3	23.4	0.4	0.9	1.8	0.2	0.0	457
12.00	41.1	26.3	32.6	44.5	28.5	26.0	2.72	10.0				71.0	21.5	0.9	1.2	3.6	1.5	0.3	335
13.00	39.9	20.2	39.9	43.8	25.1	31.0	2.59	10.2				72.3	20.1	0.3	2.7	3.6	0.6	0.3	329
14.00	41.5	28.5	30.0	45.1	32.2	22.7	2.78	9.8				70.3	18.9	0.6	2.8	6.4	1.1	0.0	360
15.00	42.3	26.1	31.6	45.8	28.9	25.3	2.75	10.0				75.2	18.7	0.6	1.4	4.0	0.0	0.0	347
16.00	42.7	26.8	30.4	46.2	31.2	22.6	2.81	10.1				68.6	22.2	1.1	2.4	5.4	0.3	0.0	368
17.00	40.9	27.2	32.0	43.4	33.2	23.4	2.56	10.4				68.7	25.4	0.0	0.9	4.5	0.6	0.0	335
18.00	41.7	25.6	32.8	45.4	30.6	24.0	2.77	10.1				71.8	20.4	0.0	2.2	4.1	0.8	0.3	362
19.00	30.4	32.8	36.8	30.9	41.6	27.5	0.43	11.9				70.5	23.0	0.0	0.0	4.9	0.0	1.6	61
20.00	44.0	26.0	30.0	47.9	29.8	22.3	3.08	10.2				70.6	20.8	0.0	3.9	3.7	0.7	0.2	408
21.00	46.6	25.7	27.7	49.1	29.5	21.5	4.07	10.1											
22.00								12.0				60.2	29.5	0.6	1.9	7.0	1.1	0.0	359
23.00	51.1	24.4	24.5	53.7	27.6	18.7	1.46	10.2											
24.00								10.3				66.5	27.8	1.2	0.4	3.7	0.4	0.0	514
25.00	50.7	23.2	26.1	52.7	27.3	20.0	5.66	9.4											
26.00								9.8				64.9	21.9	0.0	3.9	2.9	1.0	5.5	416
27.00	56.8	26.7	16.5	59.8	27.8	12.4	5.82	10.1											
28.00								9.5				61.8	29.7	0.4	3.9	2.4	1.1	0.9	464
29.00	53.5	27.8	18.6	56.6	30.0	13.4	3.56	9.9											
30.00								9.7				62.9	27.1	0.0	1.0	1.6	1.3	1.0	310
31.00	54.3	29.8	16.0	57.4	31.1	11.5	4.96	10.0											
32.00								11.6				62.3	30.6	0.3	2.5	1.8	2.5	0.0	284
33.00	53.7	28.9	17.4	56.5	30.8	12.7	3.81	10.1											
34.00								10.3				53.6	35.5	0.3	4.2	4.2	2.2	0.3	358
35.00	49.0	26.5	24.5	51.7	29.5	18.9	2.93	9.4											
36.00								10.8				51.5	41.6	0.4	2.1	4.0	0.4	0.0	478
37.00	56.2	24.3	19.5	59.1	26.7	14.2	3.37	10.1											
38.00	55.6	25.3	19.2	58.3	27.7	14.0	3.10	10.0				53.2	39.6	0.0	4.0	2.6	0.6	0.3	346
39.00	54.2	27.1	18.7	57.0	28.7	14.3	3.66	9.6											
40.00	57.4	24.7	17.8	60.1	26.5	13.3	3.20	10.1				53.7	38.3	0.2	3.0	3.5	1.2	0.2	426
41.00	58.6	25.3	16.1	61.4	25.2	13.4	3.34												
42.00								12.7				51.6	47.3	1.3	2.1	0.0	0.3	0.0	374
43.00								12.7											
44.00								9.4				54.5	41.8	0.0	2.0	0.5	1.5	0.0	407
45.00								10.6											
46.00								9.5				60.5	40.1	0.9	1.2	0.3	1.2	0.0	332
48.00	40.4	29.1	30.5	43.1	33.4	23.5	2.60	10.3				48.8	34.8	0.0	4.2	5.3	6.8	0.0	336
49.00	40.6	27.1	32.3	43.4	31.8	24.8	2.47	11.3				48.4	41.8	0.0	5.1	3.6	4.0	0.0	275
50.00	43.4	27.7	28.9	46.1	32.9	21.0	2.68	10.6											
51.00	41.1	28.7	28.2	46.1	33.0	20.9	2.70	10.1				43.2	43.8	0.6	3.9	5.1	3.6	0.3	333
52.00	43.7	26.5	29.8	46.5	31.1	22.4	2.94	10.2											
53.00	36.5	37.0	26.5	40.0	41.3	18.6	1.66	12.1				51.6	41.7	1.3	3.9	1.6	0.9	0.0	316
54.00	40.1	32.8	27.1	42.9	37.7	19.4	1.78	11.5											

T23

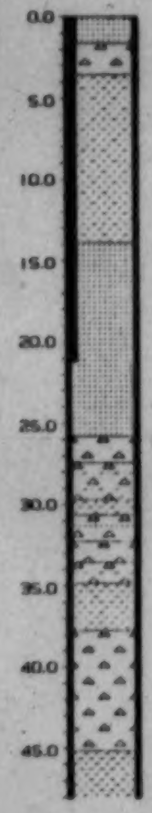
Alberta Geological Survey Testhole 1 23
Location: of LSD 15 Sec 22 Twp 64 Rng 6 W of 4 Mer. NTS 73L
Elevation: 2000 ft. 610 m Source 1:50,000 NTS 73L/10
Date drilled: 197607 27 Logged by: M FENTON



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (m)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT OSS	LST	DST	LOC	GTN	N
1.00	40.1	27.0	32.8	42.9	29.7	27.4	1.64	10.6				61.5	30.7	0.0	2.7	4.6	0.4	0.0	218
2.00	41.2	27.2	31.6	44.7	30.2	25.2	1.90	9.8				64.6	29.9	0.4	2.0	2.7	0.4	0.0	254
3.00	40.4	27.1	32.6	43.0	30.3	26.6	1.55	11.4				63.7	30.0	1.5	2.1	1.5	1.0	0.0	183
4.00	27.2	36.0	36.8	31.6	37.9	30.5	1.00	14.0				66.2	26.2	1.4	2.1	1.4	2.8	0.0	145
5.00								15.1											
6.00								15.5											
12.00								12.7											
13.00	48.8	31.4	19.8	52.6	32.7	14.7	2.56	10.5				55.8	31.7	0.0	3.6	8.2	0.3	0.0	328
14.00	49.1	29.4	21.4	54.0	30.6	15.4	2.98	10.9				53.1	33.5	0.5	3.9	7.5	1.1	0.0	388
15.00	44.9	27.1	28.0	47.7	29.8	22.5	2.44	11.8				57.3	35.2	0.8	3.6	1.9	0.6	0.0	307
16.00	38.5	30.5	31.0	41.8	37.3	20.9	2.52	12.2				58.0	34.0	0.3	2.4	3.9	1.2	0.0	329
17.00	36.5	28.9	34.6	38.8	34.6	26.5	1.93	12.2				52.9	37.9	0.8	3.8	3.1	1.5	0.0	261
18.00	35.4	29.6	35.0	38.0	34.9	27.2	2.22	11.4				55.6	36.9	0.3	4.4	2.0	0.6	0.0	295
21.00								16.0											
24.00								17.0											
25.00								15.1											
26.00								13.6											
27.00								17.1											
28.00								17.2											
29.00								15.2											
30.00	42.4	29.5	28.1	45.2	33.3	21.5	2.71	12.1				51.4	38.3	0.3	5.4	3.4	0.9	0.0	352
31.00	54.3	21.5	24.2	57.4	24.3	18.3	3.58	10.3				48.7	40.7	0.2	4.6	2.8	2.7	0.0	476
32.00	46.9	23.8	29.3	50.7	27.1	22.1	2.61	9.5				44.3	46.6	0.0	4.5	2.5	1.8	0.0	352
33.50	50.8	21.8	27.5	53.6	25.2	21.2	2.68	10.2				50.8	40.7	0.0	4.3	3.4	0.8	0.0	364
34.00	47.2	23.2	29.7	51.1	26.3	22.5	2.22	9.6				50.2	41.2	0.3	3.6	3.3	1.3	0.0	301
35.00	47.6	22.4	29.9	50.5	26.6	22.9	2.36	9.2				54.5	37.6	0.6	2.1	2.4	2.4	0.0	332
36.00	47.4	22.5	30.1	51.2	25.4	23.4	2.66	10.2				53.1	35.6	0.3	6.6	1.9	1.9	0.3	365
37.00	35.4	23.8	40.8	38.1	30.2	31.7	1.66	8.3				60.8	35.8	0.4	1.3	0.4	1.2	0.0	232
38.00	29.2	22.9	48.0	32.6	30.7	36.7	1.25	12.0				65.9	33.0	0.0	0.5	0.5	0.0	0.0	178
39.50	30.2	27.8	42.0	32.7	36.6	30.7	1.78	11.3				58.4	36.1	0.0	4.6	0.8	0.0	0.0	238
40.00	29.3	28.1	42.7	32.8	36.2	30.9	1.64	11.5				64.9	32.2	0.0	1.4	1.4	0.0	0.0	214
41.00	26.7	27.9	45.4	29.2	38.1	32.7	1.27	10.1				60.5	33.7	1.2	2.3	1.7	0.6	0.0	172
42.00	28.9	28.1	43.0	32.4	36.4	31.2	1.45	10.0				71.2	24.6	1.0	1.0	1.0	1.0	0.0	181
43.00	28.4	29.1	42.4	31.0	37.7	31.2	1.18	11.1				57.3	37.2	1.2	3.0	0.0	1.2	0.0	164
44.00	28.0	26.6	45.5	31.6	35.0	33.4	1.36	11.1				53.6	42.8	0.5	1.0	0.0	2.0	0.0	194
46.00	31.1	26.9	42.0	33.8	36.0	30.2	1.45	11.2				61.0	31.7	1.6	1.6	0.5	0.5	0.0	187
47.00	30.2	28.1	41.7	33.9	35.3	30.8	1.95	10.6				53.1	42.6	0.5	2.4	0.9	0.5	0.0	209
48.00	29.4	26.5	44.2	32.0	35.5	32.5	1.07	11.0				63.0	34.8	0.7	1.4	0.0	0.0	0.0	138

T24

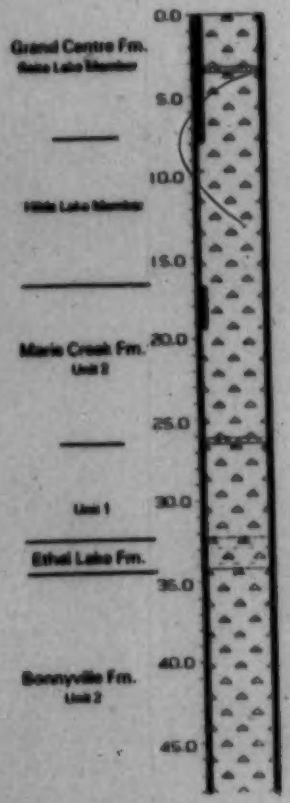
Alberta Geological Survey Testhole T 24
Location: of LSD 14 Sec 33 Twp 62 Rng 7 W of 4 Mer , NTS 73L
Elevation: 1840 Ft 561 M Source: 1:50,000 NTS 73L/7
Date drilled: 197607 29 Logged by M. FENTON



DEPTH (m)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VF SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	IOC	OTH	N
1.00																			
2.00								12.6											
3.00								10.8											
14.00								20.6											
26.00								9.6											
27.00								10.5											
28.00								11.6											
29.00								9.2											
30.00								12.3											
32.00								10.2											
38.00								11.0											
39.50								9.8											
40.00								9.4											
41.00								14.6											
42.50								10.3											
44.00								8.0											
46.00								17.3											
47.00								16.6											
48.00								15.9											

T25

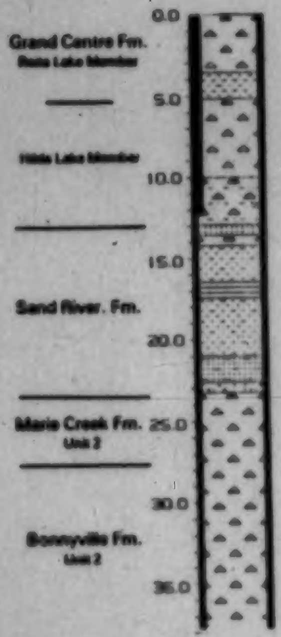
Alberta Geological Survey Testhole 1 25
Location of LSD 4 Sec 24 Twp. 62 Rng 6 W of 4 Mer. , NTS 73L
Elevation: 1830 Ft 558 M Source 1:50,000 NTS 73L/7
Date drilled: 197607 30 Logged by: M. FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	46.5	22.0	31.5	50.1	22.4	27.5	1.28	11.7	7.3	3.1	1.23								
2.00	43.8	20.2	35.9	46.5	22.6	30.9	1.62	12.8	23.7	10.0	0.33	69.9	26.6	3.5	0.0	0.0	0.4	0.0	229
3.00	36.0	27.2	36.8	38.9	30.6	30.4	1.58	14.5	26.5	11.1	0.30								
4.00	37.3	27.6	35.1	41.7	29.6	28.6	1.80	10.9	25.3	10.7	0.40	71.1	24.5	1.2	0.8	2.4	0.4	0.0	253
5.00	41.0	26.6	32.5	44.2	29.3	26.5	1.81	9.8	24.6	10.3	0.27								
6.00	38.4	24.7	36.9	43.0	23.6	33.4	1.68	10.8				64.4	30.0	2.2	2.2	0.9	0.0	0.0	223
7.00	38.6	26.9	34.5	41.9	29.3	28.8	1.38	10.6	25.8	10.8	0.20	65.9	31.3	0.0	1.6	1.1	0.0	0.0	182
8.00	32.3	29.9	37.8	37.3	33.0	29.8	1.38	12.2	26.9	10.8	0.19								
9.00	31.0	29.7	39.3	35.7	32.9	31.4	1.18	12.2	30.8	12.9	0.23	67.9	27.7	1.9	1.2	1.2	0.0	0.0	159
10.00	25.7	51.2	23.1	28.1	46.5	25.3	0.94	12.9	34.3	14.4	0.24								
11.00	27.3	32.0	40.7	30.7	38.0	31.3	0.76	11.3	32.3	13.5	0.23	61.0	32.6	1.0	1.0	3.1	1.0	0.0	95
12.00	28.8	30.2	41.0	31.4	37.3	31.3	0.85	12.1	29.8	12.5	0.27								
13.00	28.5	30.1	41.4	31.6	36.3	32.1	0.84	11.9	33.0	13.7	0.19	60.4	34.0	4.1	0.8	0.8	0.8	0.0	121
14.00	27.7	32.3	40.1	30.8	38.2	31.0	0.70	11.3	29.9	12.5	0.28								
15.00	28.2	29.9	41.8	30.5	37.2	32.3	0.77	11.7	21.8	9.1	0.27	63.4	21.5	7.5	4.3	3.2	0.0	0.0	93
16.00	31.2	32.6	36.3	34.8	36.0	29.2	1.21	11.3	29.3	12.3	0.34	66.2	25.8	0.6	1.7	5.0	0.6	0.0	160
17.00	40.4	31.5	28.1	43.6	32.5	23.9	2.78	9.1	50.2	20.8	0.11								
18.00	38.0	34.2	27.7	42.3	34.9	22.8	2.26	9.8	50.1	30.8	0.16	56.3	21.9	0.0	4.8	15.7	1.0	0.0	311
19.00	42.1	33.6	24.3	45.6	34.9	19.5	2.66	9.6	39.7	23.6	0.16								
20.00	40.6	35.7	23.6	45.2	35.9	18.9	2.79	9.6	48.6	20.2	0.14	59.5	23.1	0.6	4.9	11.6	0.0	0.0	362
21.00	42.5	33.0	24.5	45.6	36.8	17.6	2.96	9.6	47.9	19.9	0.16								
22.00	39.6	38.9	21.5	43.8	34.7	21.5	2.55	8.6	46.8	19.4	0.12	57.8	24.2	0.0	2.6	14.7	0.6	0.0	339
23.00	45.8	32.4	21.9	49.5	33.6	16.9	3.08	8.6	49.8	20.7	0.17								
24.00	38.9	36.8	24.2	43.2	38.0	18.8	2.65	8.2	44.4	18.4	0.13	58.4	26.2	0.3	2.4	13.6	0.0	0.0	330
25.00	37.9	33.2	28.9	42.1	34.6	23.3	2.45	8.1	42.8	17.8	0.15								
26.00																			
27.00	38.5	28.6	33.0	41.1	29.9	29.0	2.43	10.2	34.4	14.4	0.20	64.7	29.4	0.3	3.1	2.5	0.0	0.0	323
28.00	35.7	28.0	36.3	39.0	31.3	29.7	2.61	10.6	35.1	14.6	0.18	64.0	28.6	0.0	2.0	4.1	1.2	0.0	342
29.00	35.9	27.5	36.6	39.0	30.6	30.4	2.33	10.2	29.7	12.4	0.18								
30.00	35.9	28.9	35.2	39.2	31.4	29.4	2.19		32.0	13.4	0.23	61.4	28.1	0.0	1.4	8.8	0.3	0.0	285
31.00	32.5	26.0	41.5	35.7	28.7	35.6	2.52		29.9	12.8	0.25								
32.00	37.3	30.5	32.1	40.1	33.6	26.3	2.32		31.0	12.9	0.22	59.4	33.1	0.3	0.3	5.5	1.3	0.0	308
33.50	55.4	21.8	22.9	58.8	23.6	17.6	3.55	10.0	24.1	10.1	0.36								
34.00	70.4	16.4	13.2	72.9	16.7	10.4	5.14		27.9	11.7	0.30								
35.00	61.4	23.7	14.8	65.5	22.9	11.6	5.37	9.8	32.4	13.6	0.36	55.3	36.2	0.0	3.5	4.5	0.2	0.2	425
36.00	62.0	21.5	16.5	65.0	21.9	13.1	3.81	8.9	24.9	10.4	0.20								
37.00	59.1	23.6	17.3	63.1	23.3	13.6	4.45		25.1	10.5	0.20	53.1	37.1	0.2	3.6	3.8	0.9	0.2	557
38.00	65.0	21.4	13.6	68.0	21.2	10.8	3.77	11.1	23.0	9.6	0.19								
39.50								11.5	24.5	10.2	0.21								
40.00									29.4	12.3	0.23								
41.00									33.2	13.9	0.24								
42.50									30.6	12.8	0.23								
43.00								11.1	29.4	12.3	0.24								
44.00								11.4	27.7	11.6	0.24								
46.00	53.7	23.8	22.5	57.7	24.2	18.1	2.45	8.9	30.5	12.8	0.35								
47.00	56.6	24.7	18.7	59.3	26.6	14.1	3.27	8.3	31.7	13.3	0.25								
48.00	57.2	26.0	16.8	60.8	26.1	13.1	2.96	8.6	30.9	12.9	0.27								

T27

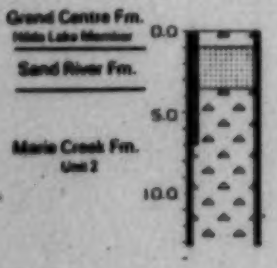
Alberta Geological Survey Testhole 1 27
Location: of LSD - 4 Sec 6 Twp 64 Rng 3 W of 4 Mer , NTS 73L
Elevation 1830 Ft 558 M Source 1:50,000 NTS 73L/9
Date drilled 197607 31 Logged By P. WATERS



DEPTH (M)	TEXTURE (%) SAND >62	SILT 9um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN MET:M	COARSE SAND LITHOLOGY (%) QTZ	QTZT VSS	LST	DST	LOC	OTH	N
1.00	39.7	27.0	33.3	43.1	29.4	27.5	1.38	12.6				69.0	25.5	1.3	2.9	1.1	0.3	0.0	377
2.00	35.6	29.6	34.9	39.2	31.5	29.3	1.27	12.7				70.4	20.7	2.0	3.1	2.8	0.9	0.0	362
3.00	32.8	27.8	39.4	36.1	30.3	33.5	1.41	13.8				61.4	30.3	2.6	1.6	3.1	1.1	0.0	386
6.00	27.2	34.2	38.6	31.3	36.5	32.2	0.80	14.8				70.9	24.5	0.9	0.9	1.7	0.4	0.0	234
7.00	27.3	33.9	38.7	32.2	35.5	32.3	0.84	14.5				71.2	25.0	1.4	1.4	0.5	0.5	0.0	212
8.00	28.4	31.6	40.0	32.0	34.0	33.9	0.98	14.9				66.7	24.9	2.5	2.5	1.8	0.4	0.0	285
9.00	28.8	28.7	42.5	31.9	33.0	35.1	0.98	14.9				69.9	25.3	1.6	0.8	1.6	0.8	0.0	249
10.00	20.7	39.2	40.2	24.7	41.0	34.3	0.97	16.4				76.8	20.5	0.9	0.0	1.4	0.5	0.0	220
11.00	28.1	30.8	41.1	31.4	34.3	34.3	1.11	15.5				72.8	21.4	2.4	1.5	1.0	1.0	0.0	206
12.00	40.8	33.4	25.8	46.0	32.9	21.1	2.23	13.7				71.8	21.5	0.5	1.8	3.3	1.1	0.0	571
14.00	38.9	27.9	33.2	43.4	29.4	27.2	1.95	12.1				70.7	23.9	1.0	1.8	1.9	0.8	0.0	515
16.00								18.5											
17.00								18.6											
18.00								20.9											
19.00								20.4											
21.00								19.3											
22.00								17.7											
24.00	40.7	33.5	25.8	44.4	35.6	20.0	2.88	9.1				64.2	18.9	1.0	2.8	12.8	0.4	0.0	721
25.00	38.2	33.6	28.1	41.8	35.7	22.5	2.45	8.8				63.4	23.6	0.0	3.1	9.1	0.9	0.0	352
26.00	40.5	31.3	28.2	44.0	33.3	22.7	2.64	8.5				66.4	21.2	0.6	3.2	8.7	0.0	0.0	345
27.00	43.2	30.7	26.1	46.8	31.8	21.4	3.11					65.8	23.0	0.6	1.4	8.4	0.3	0.0	357
28.00	51.7	27.0	21.3	55.4	27.8	16.8	3.55					59.2	28.0	0.0	4.3	7.5	0.0	0.0	255
30.00	48.1	28.1	23.8	51.9	30.0	18.1	3.32	8.6				62.8	27.6	0.6	3.8	4.6	1.2	0.0	521
31.50	47.1	28.9	24.0	50.8	30.6	18.5	3.09	9.1				62.3	28.1	0.4	4.1	2.5	3.0	0.0	517
32.00	48.4	27.5	24.1	52.1	29.5	18.4	3.19	8.4				53.1	34.8	0.0	6.4	3.9	2.0	0.0	546
33.50	48.5	27.7	23.8	52.2	29.9	17.9	3.15	8.3				58.0	30.3	0.6	4.0	2.5	3.5	0.0	476
34.00	46.1	27.5	26.4	49.8	29.8	20.4	3.01					63.3	28.1	0.3	3.3	2.4	2.4	0.0	335

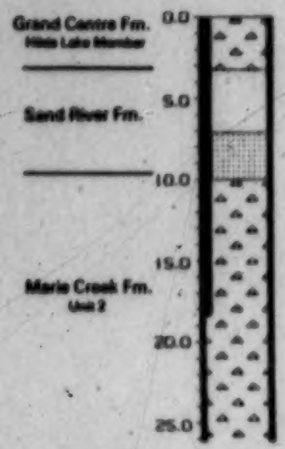
T28

Alberta Geological Survey Testhole T 28
Location: of LSD 9 Sec 34 Twp 63 Rng 2 W of 4 Mer., NTS 73L
Elevation 1850 Ft 564 M Source 1 50,000 NTS 73L/8
Date drilled: 197608 02 Logged by: P. WATERS



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
4.00	40.8	31.8	27.5	44.4	31.7	23.8	2.75	9.2				59.1	19.1	0.3	4.4	15.2	2.0	0.0	362
5.00	38.8	31.1	30.0	42.9	31.6	25.5	2.47	9.8				62.9	14.6	0.3	3.1	18.3	0.9	0.0	323
6.00	46.0	26.2	27.7	49.6	26.0	24.4	2.98	9.2				63.5	24.6	0.5	2.1	7.5	1.7	0.0	386
7.00	17.6	30.2	52.2	19.3	42.1	38.6	1.21	18.2				71.2	21.2	0.5	2.7	3.8	0.5	0.0	184
8.00								15.7											
9.00	42.7	25.6	31.7	46.3	29.0	24.7	2.76	10.8				59.0	26.3	0.9	4.9	4.6	4.1	0.0	346
10.00	44.2	26.2	29.6	48.1	29.1	22.8	2.95	9.5				60.0	28.5	0.3	3.8	4.5	2.6	0.0	397
11.00	44.5	28.9	26.6	48.4	31.4	20.3	3.25	9.7				62.8	26.1	0.2	5.1	3.3	2.8	0.0	449
12.00	47.6	28.0	24.4	51.3	29.9	18.8	3.39	9.4				67.1	23.2	0.9	4.2	2.7	1.8	0.0	453
13.00	46.9	29.5	23.6	51.1	31.0	17.9	3.87	9.2				63.6	25.8	0.4	4.7	2.4	3.0	0.0	450

T29

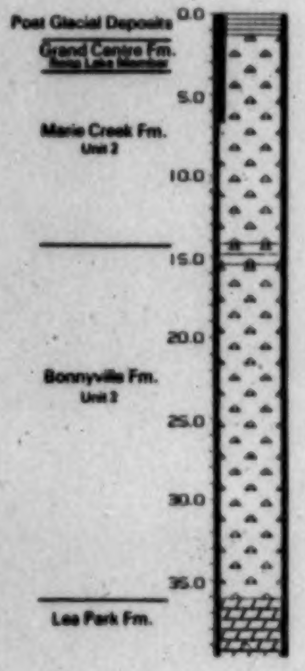


Alberta Geological Survey Testhole T 29
Location of LSD 9 Sec 34 Twp 63 Rng 2 W of 4 Mer . NTS 73L
Elevation: 1825 Ft. 556 M Source: 1 50,000 NTS 73L/8
Date drilled 197608 03 Logged by: P WATERS

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LST	DST	LDC	OTH	N
1.00	21.0	25.4	53.7	23.1	29.8	47.1	1.07	13.5				64.6	25.9	1.4	2.7	4.1	1.4	0.0	147
2.00	12.3	30.5	57.1	14.4	36.3	49.3	0.52	17.6				63.6	28.6	0.0	2.6	2.6	2.6	0.0	77
3.00	22.9	23.6	43.5	35.7	25.3	39.0	1.56	12.3				68.9	23.8	0.0	3.5	1.9	1.9	0.0	206
10.00	40.5	30.7	28.9	44.5	30.8	24.7	2.95					62.5	20.5	0.9	5.1	10.9	0.6	0.0	352
11.00	39.7	32.1	28.2	43.7	32.1	24.2	3.07	10.9				55.4	23.8	0.5	4.2	14.3	1.9	0.0	379
12.00	39.7	31.2	29.1	43.3	32.3	24.4	2.66	9.6				58.0	18.5	1.7	3.1	16.5	2.3	0.0	352
13.00	39.6	31.1	29.3	43.7	31.8	24.5	3.01	10.4				54.2	20.4	0.8	5.0	16.4	3.2	0.0	378
14.00	39.8	30.0	30.2	43.5	31.3	25.3	2.59	9.9				56.5	20.9	1.8	4.5	15.4	0.9	0.0	331
15.00	43.8	26.9	29.3	47.7	27.8	24.5	2.79	10.0				62.8	25.9	0.9	3.8	5.5	1.2	0.0	344
16.00	46.9	22.5	30.6	50.6	23.8	25.6	3.29	9.1				65.6	21.7	2.2	3.1	6.0	1.4	0.0	419
17.00	43.4	24.8	31.8	47.4	25.9	26.7	2.92	9.5				58.4	31.6	0.5	2.7	5.4	1.4	0.0	370
18.00	40.6	25.3	34.1	43.9	30.1	26.0	2.56	10.1				60.2	26.9	0.0	4.3	3.7	4.3	0.0	327
19.00	44.7	25.9	29.4	42.7	29.0	22.2	3.04	8.7				56.6	30.6	0.8	4.9	5.1	2.1	0.0	392
20.00	45.3	26.5	28.2	48.9	28.0	23.1	3.14	9.2				60.4	26.3	0.7	3.8	3.6	4.7	0.0	419
21.00	53.4	24.4	22.3	57.1	26.7	16.2	7.49	8.9				59.4	28.4	0.2	4.5	4.8	2.1	0.0	419
22.00	48.4	27.9	23.8	52.2	30.3	17.5	2.74	10.3				60.2	26.7	1.6	5.7	3.7	2.2	0.0	510
23.00	47.4	29.2	23.4	51.5	31.6	16.9	3.76	9.7				62.0	27.8	0.4	4.1	3.7	1.7	0.0	460
24.00	47.6	28.2	24.2	51.5	30.5	18.0	3.45	9.8				64.0	28.4	0.7	1.7	3.0	1.9	0.0	461
25.00	46.9	29.2	24.0	50.8	32.6	16.6	3.24	10.3				63.3	26.5	1.0	4.6	3.4	0.9	0.0	411
26.00	47.1	29.2	23.8	50.9	31.7	17.4	3.68	11.7				59.6	27.6	0.4	5.0	3.3	4.1	0.0	485

T30

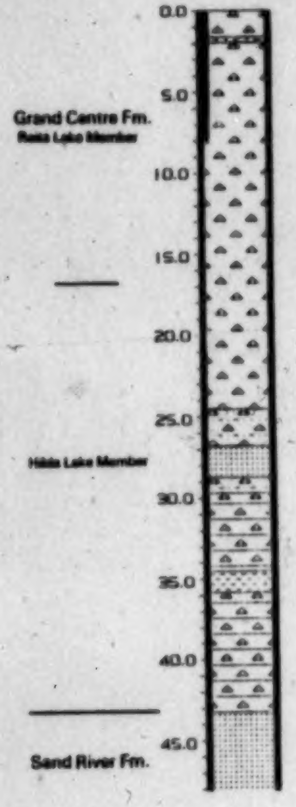
Alberta Geological Survey Testhole 1 30
Location: of LSD 13 Sec 4 Twp 62 Rng 3 W of 4 Mer , NTS 73L
Elevation: 1775 Ft 541 M Source: 1:50,000 NTS 73L/8
Date drilled: 197608 04 Logged By ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00																			
2.00	35.0	25.4	39.5	37.2	28.5	34.3	1.71	12.5	28.0	11.8	0.36	68.6	23.8	2.7	2.2	1.8	1.8	0.0	223
3.00	38.9	21.7	39.5	42.0	24.2	33.8	3.27	14.8				75.0	19.8	1.1	0.8	3.0	0.4	0.0	268
4.00	46.9	32.3	20.8	51.3	31.8	17.0	2.78	8.7	46.9	19.6	0.18	61.1	19.8	0.0	5.9	12.3	0.8	0.0	373
5.00	40.5	32.5	27.0	44.2	33.8	22.0	3.04	8.4				62.0	18.4	0.3	2.6	11.0	7.5	0.0	382
6.00	38.6	31.7	29.7	42.1	34.3	23.5	2.56	9.3	36.4	15.2	0.20	64.9	22.7	1.2	2.4	7.6	1.2	0.0	330
7.00	42.7	30.3	27.1	46.6	31.2	22.2	2.57	7.6	39.7	16.6	0.19	64.8	21.7	0.3	2.7	9.9	0.6	0.0	332
8.00	45.6	29.4	25.0	49.3	30.4	20.3	3.00	9.5				61.5	24.9	0.5	3.1	9.2	0.8	0.0	382
9.00	37.2	27.1	35.7	40.5	35.2	24.3	2.60	9.2	33.1	13.8	0.17	59.5	25.3	1.7	3.7	8.9	0.6	0.0	348
10.00	30.8	28.5	40.8	33.5	31.9	34.5	2.31	9.9				70.4	21.9	0.3	2.3	4.3	0.7	0.0	301
11.00	38.9	28.8	32.3	42.3	29.5	28.2	2.04	10.6	27.0	11.3	0.25	62.6	30.0	0.4	1.8	4.4	0.7	0.0	273
12.00	46.8	25.1	28.1	50.0	25.4	24.6	2.42	8.8				56.6	37.5	0.3	3.0	1.2	1.2	0.3	339
13.00	41.0	23.7	35.4	43.6	25.5	30.8	2.09	9.0				54.7	34.2	0.3	3.3	4.9	2.2	0.0	307
14.00	53.3	21.8	24.9	56.7	21.1	22.2	3.21	8.5				63.3	29.0	0.3	4.0	1.3	2.1	0.0	373
15.00	45.9	25.0	29.1	48.8	26.2	25.0	2.79	13.5				64.6	26.1	0.0	4.4	4.1	0.9	0.0	345
16.00	50.9	23.1	26.0	54.2	23.2	22.5	3.41	7.2				57.5	34.1	0.4	3.9	2.8	1.3	0.0	463
17.00	52.0	20.9	27.1	55.1	21.8	23.1	3.47	7.0	25.3	10.6	0.30	54.7	35.6	0.8	3.2	3.0	2.7	0.0	475
18.00	53.6	21.5	24.9	56.6	21.7	21.7	3.55	8.8				56.8	35.6	0.7	3.6	2.5	0.8	0.0	444
19.00	54.9	22.5	22.6	57.7	22.2	20.1	3.34	6.3	26.6	11.2	0.34	62.2	30.8	0.4	3.2	2.6	0.8	0.0	471
20.50	57.3	19.3	23.4	60.4	21.2	18.4	3.62	10.9				60.4	31.4	0.7	3.5	2.6	1.5	0.0	462
21.00	54.5	19.9	25.6	57.5	22.6	19.9	2.61	8.4	27.2	11.4	0.25	59.1	30.4	0.7	3.7	3.0	3.0	0.0	428
22.00	52.1	22.3	25.7	55.6	24.8	19.6	3.91	7.6				57.6	33.7	0.6	4.8	2.6	0.8	0.0	503
23.00	49.7	24.3	25.9	53.2	27.1	19.7	2.91	8.5	28.6	12.0	0.30	59.3	31.1	0.7	4.4	2.5	2.1	0.0	437
24.50	45.0	24.0	31.0	48.7	27.2	24.1	3.60	9.3				63.2	23.7	0.4	5.0	4.1	2.8	0.0	464
25.00	44.0	25.7	30.2	47.6	28.8	23.6	3.43	8.6	35.6	14.8	0.19	65.6	22.0	0.5	3.3	8.1	0.2	0.0	422
26.00	47.6	24.8	27.5	51.3	27.9	20.8	3.03	8.6				66.5	23.9	0.5	2.5	5.3	1.1	0.0	397
27.50	47.8	23.0	29.2	51.2	25.8	23.0	3.45	8.4	37.1	13.4	0.25	64.6	28.2	0.4	3.0	3.2	0.7	0.0	440
28.50	45.6	25.1	29.3	49.2	27.9	22.9	3.19	8.6				68.7	21.8	0.0	3.1	4.6	1.6	0.0	380
29.00	44.9	24.3	30.8	48.5	27.8	23.7	2.97	8.9	34.3	14.3	0.23	64.3	22.1	0.5	4.8	6.9	1.4	0.0	375
30.50	44.8	27.1	28.1	48.6	30.5	20.9	2.89	9.3				67.9	28.8	0.3	2.9	4.9	0.3	0.0	385
31.50	44.8	25.1	30.1	48.6	29.0	22.4	2.59	9.4	29.0	12.1	0.19	64.9	24.3	0.0	3.9	2.7	4.2	0.0	333
32.00	45.8	26.0	28.2	49.1	29.5	21.4	3.25	9.3				68.2	18.7	1.4	4.7	5.8	1.2	0.0	428
33.50	45.7	25.4	28.9	49.2	29.4	21.4	3.21	9.2	27.4	11.5	0.26	69.0	22.0	1.7	3.3	3.6	0.4	0.0	423
34.50	45.1	26.9	27.9	48.5	33.5	20.7	3.11	9.2				67.5	22.5	1.7	2.2	4.2	1.9	0.0	409
35.50	43.1	27.0	29.8	46.8	30.4	22.8	2.77	9.4	26.3	11.0	0.28	64.3	27.7	0.6	4.8	2.0	0.6	0.0	437
36.50								16.7											
37.50								15.7											
38.50								13.3											
39.50								15.5											

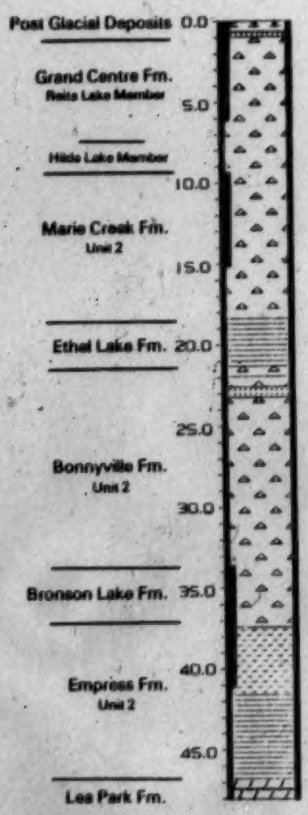
T31

Alberta Geological Survey Testhole T 31
Location of LSD 9 Sec 2 Twp 63 Rng 1 W of 4 Mer . NTS 73L
Elevation 1900 ft 579 M Source 1:50,000 NTS 73L/8
Date drilled 197608 05 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN WTM	COARSE SAND LITHOLOGY (%) QTZ	QTZT OSS	LST	DST	LOC	OTH	N
1.00	41.1	28.2	30.8	45.2	28.8	26.1	1.87	11.9				67.7	26.5	0.0	3.7	2.0	0.0	0.0	245
2.00	40.3	28.5	31.3	44.6	28.6	26.8	1.92	15.4											
3.00												74.2	20.5	1.1	0.7	3.3	0.0	0.0	268
4.00	38.1	29.6	32.3	42.6	29.8	27.6	1.78	12.2				69.7	26.0	0.8	1.3	1.1	0.4	0.0	238
5.00	39.1	26.6	34.3	42.9	27.8	29.4	2.14	13.6				71.8	17.8	0.7	1.8	7.3	1.0	0.0	287
6.00	37.5	26.2	36.3	41.4	27.9	30.7	2.04	12.7				75.3	22.9	0.7	0.4	0.4	0.7	0.0	267
7.00	38.4	25.3	36.3	42.0	27.5	30.6	2.54	12.2				80.2	17.1	0.6	0.3	1.2	0.3	0.0	334
8.00	38.0	27.1	34.9	41.9	28.4	29.7	2.11	13.5				32.3	14.9	0.0	0.7	0.7	1.0	0.0	289
9.00	38.9	26.8	34.3	42.4	28.7	28.9	3.17	12.7				74.9	20.2	0.5	1.2	2.2	0.7	0.0	411
10.00	37.5	26.3	36.3	41.4	27.5	31.2	2.02	11.9				77.2	19.8	0.4	0.4	1.1	1.1	0.0	268
11.00	38.3	25.9	35.8	41.8	27.5	30.7	2.36	12.0				75.5	19.1	1.3	1.0	2.3	0.7	0.0	298
12.00	36.0	27.5	36.5	40.4	28.4	31.3	1.44	12.0				79.9	17.6	1.0	0.5	0.5	0.5	0.0	199
13.00	37.9	24.6	37.5	41.4	27.1	31.5	2.06	10.8				76.6	20.0	0.0	0.7	0.7	1.9	0.0	265
14.00	37.7	26.0	36.3	41.7	26.9	31.4	2.28					78.0	19.4	1.0	0.0	1.6	0.0	0.0	309
15.00	36.1	28.9	34.9	40.5	31.2	28.3	1.44	11.6				73.6	21.2	1.5	1.9	2.1	0.0	0.0	193
16.00	38.3	26.3	35.4	40.4	31.3	28.2	2.36	10.8				82.6	16.8	0.0	0.0	0.3	0.3	0.0	304
17.00	25.0	32.6	42.3	28.0	39.8	32.2	0.78	12.6				69.0	27.4	0.9	0.9	1.8	0.0	0.0	113
18.00	24.6	30.9	44.5	27.3	38.9	33.9	0.99	11.4				75.6	21.5	0.0	0.7	2.2	0.0	0.0	135
19.00	26.2	27.9	46.0	29.2	35.2	35.6	0.92	12.5				76.9	18.5	2.3	0.0	1.5	0.8	0.0	130
20.00	32.1	22.9	45.1	32.6	32.4	35.1	1.36	12.0				72.2	22.5	1.8	2.9	0.0	0.6	0.0	169
21.00	24.5	30.5	45.0	27.5	38.1	34.4	1.10	12.0				80.0	19.4	0.0	0.0	0.7	0.0	0.0	139
22.00	23.1	33.1	43.8	25.7	39.5	34.8	1.04	11.7				80.7	16.0	0.8	2.5	0.0	0.0	0.0	119
23.00	28.5	28.3	43.3	31.8	34.6	33.7	0.92	11.7				66.7	27.9	0.8	3.1	1.5	0.0	0.0	128
24.00	25.8	28.7	45.5	28.3	36.1	35.6	0.80	11.8				72.5	22.0	1.8	1.8	1.8	0.0	0.0	109
25.00	31.0	30.0	39.0	34.6	35.1	30.4	0.96	11.0				75.6	22.1	0.8	0.8	0.0	0.0	0.8	131
26.00	32.3	28.5	39.2	35.4	33.2	31.4	1.07	12.1				78.5	18.5	0.8	0.8	1.5	0.0	0.0	130
27.00	34.2	31.8	34.0	38.7	33.4	27.9	1.16	9.2				75.0	22.4	1.3	0.6	0.6	0.0	0.0	152
28.00	20.3	33.7	46.0	22.4	40.8	36.8	0.64	14.7				70.3	25.3	4.4	0.0	0.0	0.0	0.0	91
29.00	17.3	37.2	45.5	19.1	45.2	35.7	0.70	13.4				70.4	27.5	1.0	0.0	1.0	0.0	0.0	98
30.00	25.1	35.3	39.6	27.7	39.1	33.2	0.99	11.1				71.3	22.9	0.8	0.8	2.4	1.6	0.0	122
31.00	19.6	30.6	49.9	21.9	38.8	39.3	0.82	14.4				79.6	18.4	0.0	1.0	1.0	0.0	0.0	103
32.00	23.8	29.1	47.1	26.2	35.9	37.9	0.82	12.5				70.5	22.8	1.9	1.9	1.9	0.0	0.0	105
33.00	29.6	26.4	44.0	33.0	31.8	35.1	0.82	11.5				77.6	20.6	0.0	0.0	1.9	0.0	0.0	107
34.00								17.1											
35.00								16.5											
36.00	18.4	25.1	56.5	20.1	37.0	42.9	0.57	10.2				75.4	20.3	2.9	0.0	0.0	1.4	0.0	690
37.00	29.3	25.7	45.0	32.5	30.7	36.8	0.88	13.1				75.4	20.9	0.9	0.9	0.9	0.9	0.0	110
38.00	10.1	27.5	62.4	12.4	40.5	47.1	0.37	15.5				59.1	31.8	6.1	1.5	1.5	0.0	0.0	66
39.00	30.4	27.3	42.4	33.7	32.2	34.1	0.97	9.9				76.1	21.5	1.5	0.8	0.0	0.0	0.0	130
40.00								14.3											
41.00								13.6											
42.00								11.9											

T32

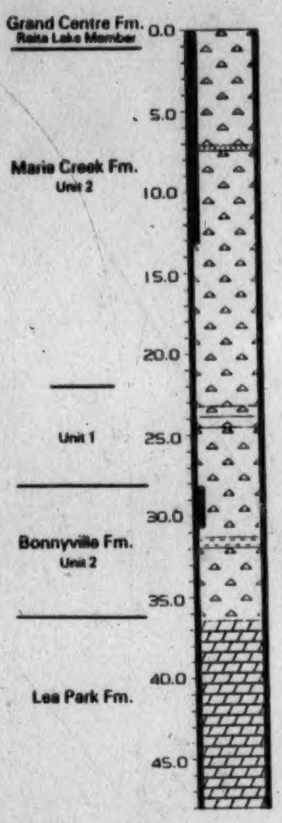


Alberta Geological Survey Testhole T 32
Location: SW of LSD 12 Sec 4 Twp 64 Rng 3 W of 4 Mer. NTS 73L
Elevation: 1800 Ft 549 M Source 1:50,000 NTS 73L/9
Date drilled: 197608 06 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00	37.0	26.0	37.0	40.0	29.0	31.0	1.86	13.3	21.4	8.9	0.24	69.6	24.4	1.2	2.3	3.8	0.0	0.0	266
2.00	36.0	25.0	38.0	40.0	28.0	33.0	1.83	15.4	29.1	12.2	0.37	65.5	28.5	0.8	2.4	2.8	0.4	0.0	249
3.00	36.0	25.0	39.0	40.0	28.0	32.0	2.00	15.6	26.2	10.9	0.24	65.6	27.8	0.7	2.6	2.2	0.4	0.0	270
4.00	37.0	26.0	37.0	41.0	28.0	31.0	1.68	14.6	25.8	10.8	0.30	64.0	27.2	2.9	1.3	4.2	1.2	0.0	239
5.00	34.0	26.0	41.0	37.0	28.0	35.0	2.99	14.5	27.6	11.6	0.28	63.9	27.0	1.3	3.5	4.4	0.4	0.0	230
6.00	32.0	26.0	42.0	35.0	29.0	35.0	1.85	14.2	26.3	11.0	0.21	64.4	26.6	2.2	2.6	4.3	0.0	0.0	233
7.00	33.0	28.0	39.0	36.0	31.0	33.0	1.65	12.3				69.3	19.1	2.7	3.1	5.3	0.8	0.0	225
8.00	26.0	28.0	46.0	30.0	31.0	39.0	1.14	14.1	25.3	10.6	0.24	69.4	22.0	0.0	4.1	4.6	0.0	0.0	173
9.00	20.0	31.0	49.0	24.0	36.0	41.0	0.72	14.1	28.2	11.8	0.25	58.8	29.8	0.0	2.6	8.8	0.9	0.0	114
10.00	38.0	30.0	31.0	42.0	32.0	26.0	2.37	8.3	43.6	18.2	0.21	67.1	16.4	0.3	3.4	10.6	1.6	0.0	161
11.00	40.0	30.0	31.0	43.0	31.0	26.0	2.54		41.3	17.2	0.19	66.3	15.6	0.6	2.8	13.4	1.2	0.0	320
12.00	40.0	28.0	31.0	45.0	29.0	26.0	2.35	10.0	43.7	18.2	0.16	65.9	19.6	0.3	2.4	10.1	2.0	0.0	296
13.00	41.0	28.0	32.0	44.0	31.0	25.0	2.43	8.2	38.6	16.1	0.15	63.1	19.6	2.0	5.1	8.7	1.9	0.0	312
14.00	46.0	27.0	27.0	50.0	29.0	22.0	2.48	8.7				61.4	23.5	1.2	4.0	7.1	2.4	0.0	324
15.00	51.0	27.0	21.0	56.0	27.0	17.0	3.64	7.1	29.3	12.2	0.25	58.7	30.4	1.1	3.4	5.0	1.0	0.0	477
16.00	55.0	23.0	22.0	58.0	24.0	18.0	3.06	6.6	30.[illegible]	12.6	0.28	56.7	32.0	0.2	4.6	4.8	1.6	0.0	413
17.00	56.0	23.0	22.0	60.0	23.0	18.0	2.76	7.2	30.7	12.8	0.23	55.5	34.7	0.5	3.7	3.7	2.1	0.0	404
18.00	46.0	27.0	28.0	49.0	30.0	21.0	2.56	7.8	29.1	12.2	0.26	59.2	30.9	0.3	2.1	4.5	3.0	0.0	333
19.00								19.6											
20.00								18.8											
21.00	31.0	25.0	44.0	34.0	34.0	32.0	1.18	15.6	15.5	6.5	0.42	49.0	45.0	3.3	0.7	1.3	0.7	0.0	151
22.00	40.0	25.0	35.0	42.0	35.0	23.0	2.71	11.5				54.4	39.7	2.0	2.6	0.0	1.4	0.0	388
23.00	52.0	30.0	18.0	56.0	33.0	11.0	3.16	8.7	20.5	8.6	0.35	59.1	34.5	1.8	3.0	0.5	1.4	0.0	438
24.00	53.0	28.0	19.0	56.0	30.0	14.0	3.44	8.9				53.4	40.5	1.0	1.9	1.5	1.6	0.0	474
25.00	52.0	29.0	19.0	56.0	31.0	14.0	3.37	8.7	20.7	8.7	0.30	58.4	35.8	0.9	1.3	0.9	2.6	0.0	450
26.00	53.0	29.0	18.0	57.0	30.0	14.0	3.36	8.5				60.7	33.5	1.2	2.1	0.7	1.9	0.0	427
27.00	53.0	28.0	19.0	57.0	30.0	14.0	3.29	8.0	20.5	8.6	0.32	60.1	34.6	0.2	3.0	1.6	0.4	0.0	436
28.00	54.0	26.0	20.0	58.0	28.0	14.0	3.36	8.3				58.7	34.3	1.6	2.0	2.0	1.1	0.0	443
29.00	53.0	26.0	21.0	57.0	27.0	16.0	3.41	8.1	20.0	8.4	0.25	56.0	38.0	0.4	1.9	1.0	2.5	0.0	484
30.00	53.0	26.0	22.0	56.0	28.0	16.0	3.61	9.1				60.5	33.5	1.4	1.9	1.7	1.0	0.0	483
31.00	54.0	25.0	21.0	58.0	27.0	15.0	4.64	10.3	18.0	7.9	0.27	56.2	35.5	1.2	2.7	1.5	2.8	0.0	598
32.00	53.0	25.0	22.0	56.0	27.0	17.0	3.75	7.8				54.1	38.4	1.4	3.2	1.6	1.4	0.0	497
33.50	23.0	34.0	43.0	28.0	35.0	38.0	0.74	12.1	20.4	8.6	0.36	38.3	45.2	2.6	4.4	1.7	7.8	0.0	116
34.00	24.0	34.0	43.0	28.0	35.0	37.0	0.80	13.3				57.5	28.3	0.0	5.0	3.3	5.8	0.0	120
35.00	23.0	34.0	43.0	28.0	35.0	37.0	0.80	13.7	21.4	9.0	0.31	57.5	28.3	0.0	5.0	3.3	5.8	0.0	120
36.50	24.0	31.0	45.0	28.0	33.0	39.0	0.76	12.0				34.3	44.4	0.0	3.7	5.6	12.1	0.0	108
37.00	6.0	41.0	53.0	8.0	48.0	44.0	0.14	16.6				21.4	17.9	0.0	0.0	3.6	57.1	0.0	28
38.00								18.7											
39.50								16.0											
40.00								18.4											
41.00								14.9											
42.50								16.3											
43.00								17.5											
44.00								15.7											
45.00								18.2											
46.00								20.4											
47.00								19.5											

T33

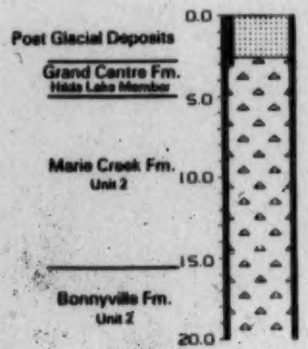
Alberta Geological Survey Testhole: 1 33
Location of LSD 5 Sec 32 Twp 65 Rng 1 W of 4 Mer . NTS 73L
Elevation 1900 Ft 579 M Source 1 50,000 NTS 73L/9
Date drilled: 197608 09 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1.00	41.0	17.0	41.0	45.0	19.0	37.0	2.60	12.9				70.0	25.4	0.6	0.9	2.6	0.6	0.0	343
2.00	41.0	26.0	33.0	45.0	28.0	27.0	2.78	11.5	39.5	16.4	0.17	58.6	21.1	0.8	5.2	9.3	4.9	0.0	365
3.00	43.0	26.0	31.0	47.0	27.0	26.0	3.11	10.4	38.0	15.8	0.17	52.5	32.3	0.0	2.8	12.6	0.0	0.0	316
4.00	43.0	26.0	31.0	47.0	27.0	26.0	2.76	10.0	34.9	14.5	0.16	66.8	20.3	1.1	3.7	7.4	0.6	0.0	353
5.00	44.0	27.0	29.0	48.0	28.0	25.0	3.09	10.2	37.1	15.4	0.16	65.1	29.5	0.5	4.2	6.9	0.7	0.0	404
6.00	44.0	34.0	21.0	48.0	34.0	18.0	3.21	10.7	36.8	15.3	0.13	68.0	19.3	0.0	3.8	7.8	1.2	0.0	425
7.00	39.0	23.0	38.0	43.0	25.0	33.0	2.50		28.6	12.0	0.26	69.0	19.7	0.9	2.8	5.9	1.6	0.0	319
8.00	47.0	24.0	29.0	51.0	25.0	24.0	2.76	10.8				63.0	24.7	0.8	4.0	6.2	1.3	0.0	375
9.00	46.0	25.0	29.0	51.0	26.0	24.0	2.70	9.3	27.4	11.5	0.31	63.0	28.3	0.3	4.0	2.0	2.3	0.0	346
10.00	47.0	32.0	21.0	52.0	33.0	15.0	2.52	9.7				64.1	27.3	0.6	4.1	3.3	0.6	0.0	337
11.00	47.0	26.0	27.0	52.0	26.0	22.0	2.57	9.8	28.0	11.8	0.33	64.2	26.2	0.3	3.8	3.5	2.0	0.0	344
12.00	49.0	24.0	27.0	53.0	24.0	23.0	3.07	8.6				60.4	32.2	0.0	3.6	2.4	1.4	0.0	419
13.00	48.0	25.0	27.0	52.0	26.0	23.0	3.13	9.2	28.7	12.1	0.35	65.8	23.3	1.0	4.1	1.8	3.6	0.2	386
14.00	48.0	30.0	23.0	52.0	32.0	16.0	3.06	10.0				62.1	28.3	1.0	2.8	3.0	2.8	0.0	396
15.00	46.0	34.0	20.0	50.0	37.0	13.0	2.73	10.5	28.3	11.9	0.33	60.6	30.4	0.3	3.7	3.4	1.4	0.0	348
16.00	48.0	31.0	21.0	52.0	33.0	15.0	3.28	9.6				63.7	23.1	0.2	6.6	4.0	2.1	0.2	424
17.00	48.0	33.0	18.0	53.0	35.0	12.0	2.92	10.0	28.6	12.0	0.28	62.9	27.8	0.7	3.0	4.3	1.2	0.0	399
18.00	49.0	35.0	17.0	53.0	35.0	12.0	3.40	9.0				57.9	32.0	0.5	3.8	3.8	1.9	0.2	425
19.00	48.0	35.0	17.0	52.0	36.0	12.0	3.13	9.0	29.5	12.4	0.32	66.8	24.7	0.8	3.6	2.5	1.5	0.0	392
20.00	47.0	35.0	18.0	51.0	37.0	12.0	2.78	9.7				64.0	27.1	0.0	2.6	4.4	1.8	0.0	383
21.00	47.0	33.0	20.0	52.0	36.0	12.0	2.95	9.5	32.3	13.5	0.27	63.3	26.1	0.0	4.7	4.2	1.0	0.0	379
22.00	43.0	30.0	27.0	47.0	35.0	18.0	2.80	10.3	25.9	10.8	0.24	67.6	23.2	0.8	2.6	4.0	1.7	0.3	349
23.00	23.0	36.0	42.0	25.0	46.0	30.0	1.64	11.4	14.9	6.3	0.42	66.3	28.0	0.9	2.3	1.9	0.5	0.0	214
24.00	42.0	29.0	29.0	47.0	33.0	20.0	1.39	11.8	13.3	5.6	0.32	66.0	29.2	0.0	3.3	0.9	0.5	0.0	212
25.00	49.0	29.0	22.0	57.0	27.0	16.0	1.18	12.5	15.9	6.7	0.48	68.4	27.1	0.0	1.3	3.2	0.0	0.0	155
26.00	36.0	29.0	35.0	39.0	36.0	25.0	1.72	11.6	10.9	4.6	0.47	67.5	27.9	1.7	2.1	0.4	0.0	0.4	240
27.00	31.0	40.0	29.0	40.0	39.0	21.0	1.54	12.1	14.8	6.3	0.40	66.5	29.5	0.5	1.5	1.0	1.0	0.0	200
28.00	42.0	30.0	28.0	46.0	31.0	23.0	2.70	11.5	19.5	8.2	0.42	60.8	30.5	0.3	5.3	1.9	1.1	0.0	360
29.00	40.0	31.0	29.0	45.0	31.0	24.0	2.41	11.8	23.0	9.7	0.41	57.5	34.7	0.3	3.6	1.5	2.4	0.0	334
30.00	31.0	32.0	37.0	34.0	41.0	25.0	2.10	12.6	31.7	13.3	0.36	51.6	33.1	0.0	10.2	3.3	5.4	0.0	275
31.00								20.4											
32.00	47.0	32.0	21.0	51.0	35.0	14.0	3.13	9.7	32.0	13.4	0.25	56.5	35.5	0.5	3.8	2.4	1.2	0.2	423
33.00	47.0	31.0	21.0	51.0	35.0	14.0	3.64	10.4	30.2	12.7	0.26	58.4	31.9	0.4	4.8	2.2	2.2	0.0	454
34.00	46.0	33.0	21.0	50.0	36.0	14.0	3.23	10.8	31.1	13.0	0.21	54.6	34.6	0.2	5.1	2.5	2.8	0.0	430
35.00	46.0	33.0	21.0	50.0	36.0	13.0	3.21	10.7	30.2	12.7	0.26	58.4	31.0	0.5	5.5	2.2	2.4	0.0	416
36.00								16.3											
37.00								16.5											
38.00								16.0											
39.00								16.0											
40.50								16.9											
41.00								15.9											
42.00								16.3											
43.00								16.1											
44.00																			
45.00								14.7											
46.00								14.2											
47.00								16.5											
48.00								15.3											

T34

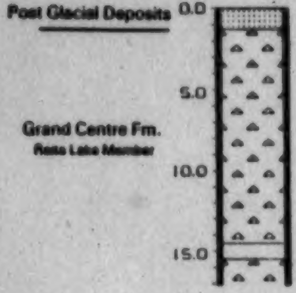
Alberta Geological Survey Testhole T 34
Location: SW of LSD 13 Sec 18 Twp 63 Rng 2 W of 4 Mer , NTS: 73L
Elevation: 1760 Ft. 537 M Source. 1 50,000 NTS 73L/8
Date drilled: 197608.10 Logged by: ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METH	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LST	DST	LOC	OTH	N
3.00	32.0	27.6	40.5	35.0	31.6	33.3	1.67	12.3				65.2	28.3	0.6	2.1	3.1	0.6	0.0	477
4.00	33.0	24.2	42.8	36.1	28.6	35.2	1.63	12.3				66.9	24.8	0.9	1.6	5.3	0.5	0.0	435
5.00	30.9	25.5	43.6	34.3	29.8	35.9	1.24	13.8				63.4	26.0	1.6	3.6	4.1	1.1	0.3	366
6.00	50.3	24.5	25.2	54.0	25.9	20.1	3.15	10.0				63.0	26.5	0.0	3.9	2.7	4.7	0.0	259
7.00	58.2	21.8	20.0	62.0	22.1	15.9	3.96					62.5	27.8	0.4	3.5	3.5	2.3	0.0	259
8.00	39.4	24.2	36.4	42.5	27.4	30.1	2.67	11.1				61.2	26.0	0.2	3.3	2.9	6.4	0.0	420
9.00	47.6	25.7	26.7	51.4	27.2	21.5	3.61	9.8				65.8	23.6	1.4	4.2	3.5	1.4	0.0	284
10.00	47.5	26.1	26.4	51.2	27.7	21.1	3.37	9.7				61.2	26.4	0.4	4.3	3.1	4.3	0.4	258
11.00	45.4	24.5	30.1	49.0	27.0	24.0	3.50	9.5				65.8	26.0	0.0	3.5	2.7	2.0	0.0	404
12.00	47.6	23.8	28.6	51.2	26.2	22.7	3.87	8.9				60.3	26.2	2.6	4.6	3.6	2.6	0.0	302
13.00	47.8	26.6	25.6	51.5	29.4	19.1	3.96	9.2				66.1	24.1	0.4	3.9	3.9	1.6	0.0	257
14.00	46.9	26.4	26.7	50.5	29.7	19.8	3.31	9.6				59.3	28.0	0.7	5.1	3.3	3.3	0.4	275
15.00	48.1	25.2	26.7	51.7	28.6	19.6	4.58	9.7				76.6	20.3	0.6	0.8	1.1	0.3	0.3	360
16.00	48.0	25.9	26.1	51.7	29.3	18.9	3.40	9.2				62.3	27.8	0.7	4.0	2.2	2.6	0.4	273
17.00	48.6	25.3	26.1	52.3	28.8	13.9	3.71	9.4				53.9	34.8	0.8	3.5	3.1	3.9	0.0	256
18.00	47.7	26.5	25.8	51.2	30.1	18.7	3.60	9.2				55.0	33.6	0.8	5.0	3.4	2.3	0.0	262
19.00	47.6	25.3	27.2	51.2	28.6	20.2	3.21	10.2				54.1	35.5	0.7	3.0	3.9	2.5	0.2	434
20.00	47.6	27.4	25.0	51.2	31.0	17.9	3.46	10.3				55.8	31.8	0.8	5.0	5.0	1.2	0.0	258

T36

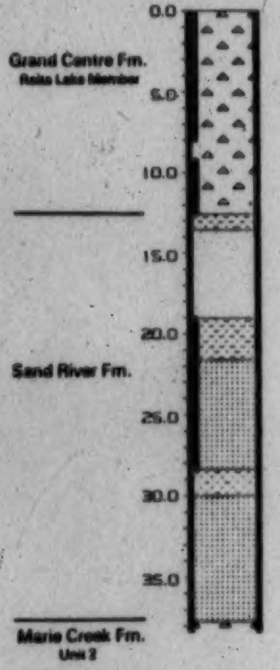
Alberta Geological Survey Testhole 1 35
Location: of LSD 12 Sec 27 Twp 63 Rng 7 W of 4 Mer , NTS: 73L
Elevation: 1875 Ft 572 M Source: 1:50,000 NTS 73L/1
Date drilled: 19760811 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/MG	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00																			
2.00	35.3	28.4	36.3	38.8	31.6	29.6	1.75	17.3				66.0	30.2	0.5	0.5	1.8	0.9	0.0	218
3.00	30.6	31.0	38.4	34.6	35.0	30.4	1.22	13.0				64.2	27.2	2.3	3.5	2.9	0.0	0.0	173
4.00	33.2	28.3	38.5	36.6	33.3	30.1	1.52	11.9				73.3	22.0	0.5	1.5	2.1	0.5	0.0	195
5.00	34.9	28.4	36.8	38.7	32.7	28.6	1.52	11.4				67.6	25.1	1.0	2.9	2.9	0.5	0.0	207
6.00	33.2	26.1	40.8	36.4	31.5	32.1	1.78	12.0				71.7	21.4	1.3	1.7	3.9	0.0	0.0	233
7.00	35.1	27.9	36.9	39.2	32.1	28.7	1.56	12.1				70.3	24.0	0.5	0.5	2.0	0.0	0.0	200
8.00	32.4	30.6	37.0	36.4	35.8	27.8	1.29	12.6				65.7	28.3	0.0	2.8	1.6	0.5	0.0	181
9.00	31.1	30.6	38.3	34.8	37.1	28.1	1.24	12.9				60.2	27.6	0.0	2.8	3.3	0.5	0.0	171
10.00	33.0	28.6	38.4	37.1	34.6	28.3	1.36	11.6				67.0	27.0	1.7	1.7	2.3	0.0	[illegible]	171
11.00	32.9	28.9	38.3	36.5	35.1	28.3	1.46	12.1				65.3	28.3	1.2	1.7	2.9	0.6	[illegible]	173
12.00	36.2	27.9	05.9	40.2	32.9	26.9	1.68	11.3				60.7	32.3	0.4	2.2	3.5	0.9	0.0	229
13.00	36.4	25.7	38.0	40.3	32.8	26.8	1.57	11.4				66.7	26.3	0.5	1.5	4.0	1.0	0.0	201
14.00	34.9	27.4	37.7	39.2	33.4	27.3	1.41	11.8				61.0	32.4	0.0	3.3	3.3	0.0	0.0	182
16.00								11.2											
17.00								10.3											

T36

Alberta Geological Survey Testhole T 36
Location: of LSD 13 Sec 4 Twp 63 Rng 6 W of 4 Mer , NTS 73L
Elevation: 1860 Ft 567 M Source: 1:50,000 NTS 73L/7
Date drilled: 197608 11 Logged by M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								10.3											
2.00	34.7	25.8	39.5	38.1	27.8	34.1	1.57	10.9				69.8	24.3	2.5	0.9	1.8	0.5	0.0	202
3.00	33.4	26.4	40.2	36.9	28.0	35.1	1.57	11.3				67.6	27.9	1.5	1.0	2.0	0.0	0.0	204
4.00	34.5	26.1	39.3	38.1	27.6	34.3	1.78	13.5				70.4	23.3	0.9	2.2	1.8	1.3	0.0	223
5.00	32.9	25.5	41.6	36.4	27.6	36.0	1.38	13.0				68.9	27.7	0.0	0.6	2.8	0.0	0.0	177
6.00	35.3	26.3	38.3	38.8	27.7	33.5	1.37	13.5				62.6	27.8	2.5	3.5	2.0	2.0	0.0	198
7.00	25.4	28.5	46.1	28.3	31.3	40.4	0.88	15.8				65.5	27.6	1.7	0.0	2.6	2.6	0.0	116
8.00	19.4	25.2	55.5	21.7	29.7	48.5	0.72	15.1				72.5	21.6	2.0	2.0	0.0	2.0	0.0	102
9.00	39.1	26.2	34.6	43.8	26.2	30.0	1.60	10.6				58.6	38.4	0.4	0.4	1.3	1.3	0.0	237
10.00	34.1	30.9	35.0	38.4	31.8	29.8	1.24	9.5				73.9	21.8	0.6	0.6	2.4	0.6	0.0	156
11.00	38.6	29.5	31.9	43.5	29.0	27.5	1.90	8.8				74.9	22.5	1.3	0.0	1.3	0.4	0.0	231
12.00	35.5	32.3	32.2	40.3	32.1	27.5	1.45	10.4				77.5	19.8	0.0	1.1	1.6	0.0	0.0	187
16.00								6.4											
19.00								10.4											
38.00	46.4	34.5	19.1	50.9	33.8	15.2	1.98	10.8				62.8	25.1	0.0	2.8	6.3	0.8	0.4	253

T37

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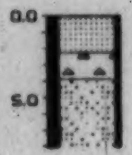
Alberta Geological Survey Testhole:   T  37
Location:      of LSD  8 Sec 26 Twp  64 Rng  7 W of 4 Mer  .  NTS  73L
Elevation:  1975Ft     602 M   Source  1 50,000 NTS 73L/11
Date drilled:   197608 15  Logged by  M  FENTON

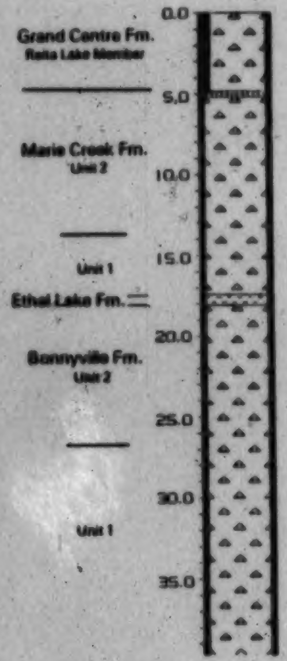
                 TEXTURE (%)                          MATRIX CARBONATE          COARSE SAND LITHOLOGY (%)
 DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H2U    CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
  (M) >62 5um     <4um  >50um     <2um 1-2mm   (%)   (cc)  (%)          METM       OSS

  3.00                                         11.4
  3.90                                         11.1
```



T38

Alberta Geological Survey Testhole I JB
Location of LSD 4 Sec 36 Twp 64 Rng 7 W of 4 Mer NTS 73L
Elevation 2000 Ft 610 M Source 1 50,000 NTS 73L/10
Date drilled 197608 15 Logged by M FENTON



DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO
	TEXTURE (%)										
2.00	46.3	22.9	30.8	50.0	23.5	26.5	1.96	10.6			
3.00	42.4	25.8	31.8	46.4	26.3	27.3	1.93	10.7			
4.00	43.0	24.4	32.6	46.7	25.2	28.1	1.89	7.7			
5.00	41.8	29.0	29.2	45.7	30.1	24.3	2.60	11.3			
6.00	42.8	29.3	27.8	46.9	31.9	21.2	2.91	9.3			
7.00	43.0	31.9	25.1	47.1	34.4	18.4	2.97	9.6			
8.00	43.8	29.9	26.4	47.7	32.9	19.5	2.61	9.6			
9.00	44.2	29.4	26.5	48.2	32.5	19.3	2.89	10.7			
10.00	44.6	28.4	27.0	48.5	31.6	20.0	2.78	10.7			
11.00	40.5	30.4	29.1	44.5	33.6	21.9	2.51	11.4			
12.00	43.8	26.5	29.6	47.8	29.6	22.6	2.67	11.6			
13.00	41.4	28.5	30.0	45.3	32.4	22.2	2.66	11.4			
14.00	36.4	27.9	35.6	40.0	31.9	28.1	3.08	11.4			
15.00	35.6	26.3	38.1	39.2	30.5	30.2	2.23	12.1			
16.00	34.3	26.2	39.5	38.1	30.8	31.1	2.21	12.2			
17.00								12.8			
18.00	49.4	22.5	28.1	53.1	25.8	21.1	2.34	5.8			
19.00	48.8	23.6	27.7	52.7	27.6	19.7	2.49	10.6			
20.00	47.3	23.0	29.7	51.0	27.6	21.4	2.12	10.4			
21.00	46.3	23.2	30.5	50.2	27.5	22.3	2.50	10.4			
22.00	44.4	24.0	31.5	48.3	28.7	22.9	2.62	10.3			
23.00	45.6	22.9	31.4	49.4	27.6	22.9	2.20	11.0			
24.00	46.4	31.7	21.8	46.8	38.0	15.1	2.77	10.6			
25.00	43.0	31.9	25.1	46.8	37.2	16.0	2.33	10.5			
26.00	43.7	28.9	27.4	47.4	32.8	19.8	2.41	10.8			
27.00	36.4	33.2	30.4	39.9	38.6	21.5	1.51	10.3			
28.00	34.4	32.9	32.6	37.8	39.6	22.6	1.56	10.4			
29.00	32.7	34.1	33.2	36.4	39.7	23.9	1.52	11.5			
30.00	31.7	34.9	33.4	35.3	41.8	22.9	1.47	10.6			
31.00	31.2	35.1	33.7	34.7	41.5	23.9	1.39	11.3			
32.00	28.6	34.4	37.0	32.1	41.3	26.6	1.45	12.8			
33.50	30.1	36.8	33.1	33.4	43.5	23.1	1.23	11.5			
34.00	29.6	31.0	39.4	33.2	38.5	28.4	1.44	10.6			
35.00	30.3	34.7	35.0	33.7	42.7	23.6	1.50	10.7			
36.50	30.1	30.4	39.5	33.8	37.4	28.8	1.55	10.6			
37.00	25.1	33.6	41.2	28.4	41.5	30.1	1.27	10.8			
38.00	24.1	32.0	43.8	27.7	39.7	32.6	1.09	11.7			
39.50	26.0	35.8	38.3	28.8	42.0	29.2	1.23	12.0			

IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
COARSE SAND LITHOLOGY (%)							
65.3	27.8	2.8	1.2	2.8	0.0	0.0	248
63.5	25.4	2.8	1.6	5.6	1.2	0.0	252
60.9	29.7	2.3	1.6	5.1	0.4	0.0	256
59.5	25.5	0.6	3.4	10.4	0.6	0.0	326
53.5	33.2	1.0	3.9	7.0	1.0	0.3	383
56.8	32.6	0.3	5.0	3.6	1.4	0.3	358
54.6	35.8	0.3	3.0	5.1	1.5	0.0	335
52.6	33.7	0.9	3.7	7.1	2.2	0.3	323
58.9	32.5	0.3	3.0	3.5	2.4	0.0	338
54.8	29.9	0.0	3.0	2.1	1.2	0.0	270
57.3	35.6	0.3	3.9	1.9	2.3	0.0	309
56.7	33.2	0.7	5.5	1.4	2.0	0.3	289
55.8	37.9	0.6	3.8	1.2	1.2	0.0	319
62.0	28.9	0.0	4.6	1.7	2.9	0.3	350
51.0	40.9	0.3	3.2	2.3	1.9	0.3	308
60.2	31.6	5.8	2.0	5.0	0.9	0.0	342
61.0	33.6	0.0	1.6	2.6	1.3	0.3	387
61.0	29.9	0.6	3.8	4.1	1.3	0.0	318
57.0	34.0	0.5	2.5	0.5	2.0	0.0	200
54.6	39.2	0.0	2.6	3.6	0.5	0.0	194
64.6	28.5	1.4	4.2	2.8	0.0	0.0	144
67.1	32.3	0.0	4.3	3.7	1.2	0.0	161
53.3	40.1	1.5	2.0	4.1	0.5	0.0	197
52.3	39.0	1.2	4.6	1.2	1.7	0.0	172
64.7	28.3	0.5	4.3	1.6	0.5	0.0	187
60.7	32.0	0.6	3.4	4.5	0.0	0.0	178
59.7	29.8	0.0	4.0	4.0	2.3	0.0	176
59.8	33.9	1.7	3.4	1.7	0.0	0.0	174
58.4	32.3	1.2	3.7	2.5	1.8	0.0	161
54.6	37.9	0.0	2.5	3.1	1.9	0.0	161

T39

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Alberta Geological Survey testhole    T 39
Location:      of LSD  1 Sec 17 Twp  62 Rng  7 W of 4 Mer ,  NTS: 73I
Elevation:  1915 Ft      584 M   Source  1:50,000 NTS 73L/6
Date drilled     197608 16  Logged by  M  FENTON

                  TEXTURE (%)                              MATRIX CARBONATE          COARSE SAND LITHOLOGY (%)
DEPTH  SAND SILT CLAY  SAND-SILT CLAY VC SD   H2O   CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
 (M) >62 5um     <4um  >50um     <2um 1-2mm   (%)   (cc)  (%)        METM       QSS

  4.00                                        8.2
  5.00                                        7.6
  6.00                                        6.2
  7.00                                       11.1
  8.00                                        8.1
  9.00                                       11.7
 10.00                                       10.3
 11.00                                       10.8
 12.00                                       15.1
 13.00                                       14.3
 14.00                                        9.7
 15.00                                       15.1
 16.00                                       14.6
 17.00                                       14.7
 18.00                                       11.4
 19.00                                       11.9
 20.00                                       21.9
 42.50                                        9.8
 43.00                                        9.2
 44.00                                        8.7
 45.00                                        9.1
 46.00                                       13.3
 47.00                                       10.6
```
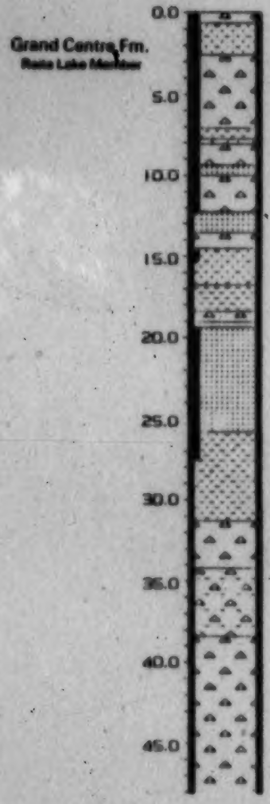
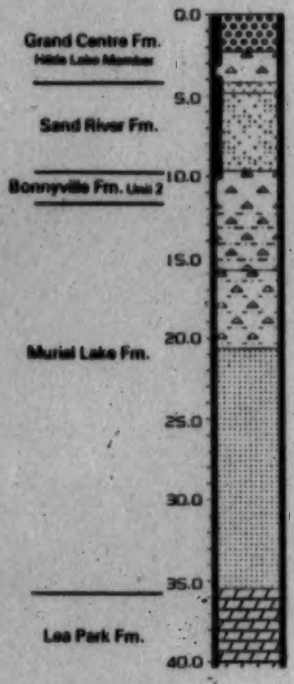


Grand Centre Fm.
Reita Lake Member
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0

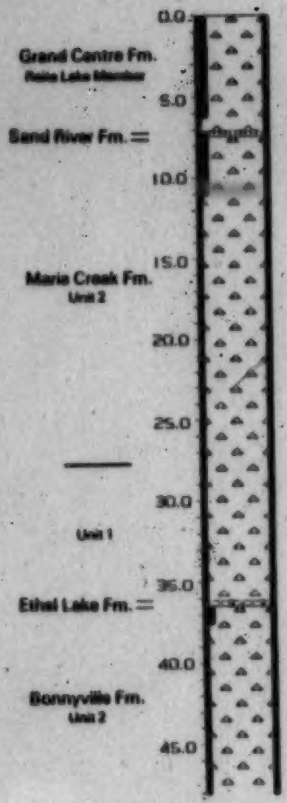
T40


Grand Centre Fm.
Hilda Lake Member
Sand River Fm.
Bonnyville Fm. Unit 2
Muriel Lake Fm.
Lea Park Fm.
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0

Alberta Geological Survey Testhole 1 20
Location of LSD 4 Sec 29 Twp 62 Rng 6 W of 4 Mer., NTS 73L
Elevation: 1780 ft. 543 M Source: 1:50,000 NTS 73L/7
Date drilled: 197608 19 Logged By: M. FENTON

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)					
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00								9.5											
2.00	25.7	29.2	45.1	28.8	34.1	37.0	0.82	12.1				67.9	26.6	1.8	0.9	2.7	0.0	0.0	108
3.00	25.8	26.6	47.6	28.8	33.0	38.2	0.86	12.0				72.3	19.6	1.8	1.8	3.6	0.9	0.0	112
4.00	38.0	26.7	35.3	41.9	28.5	29.6	1.71	10.3				71.6	23.4	0.4	1.3	3.1	0.0	0.0	222
5.00	9.1	69.8	21.2	18.5	64.1	17.4	0.02	16.8				22.2	11.1	0.0	0.0	0.0	66.7	0.0	90
10.00	58.2	23.8	18.1	61.6	24.4	14.1	3.40	9.6				57.0	36.6	0.0	2.9	1.8	1.6	0.0	442
11.00								8.9											
12.00								9.2											
13.00								9.5											
14.00								10.7											
15.00								9.6											
16.00								15.3											
17.00								19.0											
18.00								11.3											
19.00								13.0											
20.00								19.5											
36.50								16.8											
38.00								17.0											

T41

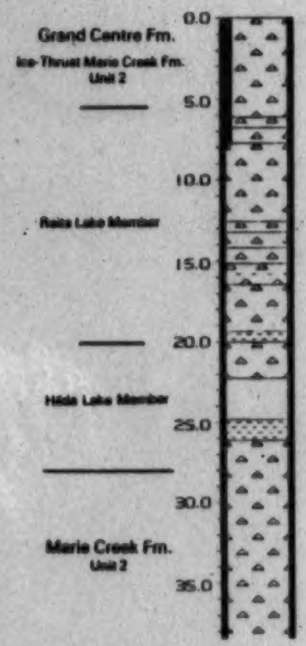


Alberta Geological Survey Testhole T-41
Location NE of LSD 3 Sec 29 Twp 58 Rng 3 W of 4 Mer . NTS 73L
Elevation 2125 ft   648 M Source 1:50,000 NTS 73L/1
Date drilled 1976 08 21 Logged by: ANDRIASHEK

DEPTH	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
(M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	32.3	25.8	41.9	34.7	28.6	36.7	1.40	13.9				79.6	19.9	0.0	0.0	0.0	0.5	0.0	196
2.00	36.5	28.0	35.5	40.5	29.5	30.0	1.73	12.0				66.8	26.1	0.4	1.7	4.2	0.4	0.4	238
3.00	34.0	27.1	38.9	36.9	29.9	33.2	1.52	15.3				60.9	32.1	0.5	2.8	1.9	1.9	0.0	215
4.00	38.9	26.4	34.7	42.3	28.2	29.5	1.58	14.0				69.0	24.8	0.0	0.8	3.1	2.3	0.0	129
5.00	37.1	29.4	33.5	41.7	29.6	28.7	1.57	14.0				66.1	28.0	0.0	2.8	2.8	0.0	0.0	218
6.00	33.0	25.1	42.0	35.7	27.7	36.6	1.44	13.2				62.7	29.9	0.5	2.0	3.0	2.0	0.0	201
7.00	30.7	27.7	41.5	34.9	30.8	34.3	0.92	11.9				57.5	37.0	0.0	2.4	2.4	0.8	0.0	127
8.00	36.0	32.0	32.0	39.3	33.8	27.0	2.43	10.9				56.8	27.0	0.0	3.4	12.1	0.7	0.0	296
9.00	37.7	31.5	30.8	41.9	32.9	25.2	2.49	9.0				59.9	27.4	0.0	2.9	8.3	1.5	0.0	339
10.00	37.1	29.2	33.6	40.5	31.2	28.3	1.45	8.9				58.0	28.8	0.0	3.7	8.2	1.2	0.0	243
11.00	34.2	30.2	35.5	38.0	32.1	29.9	2.48	9.5				62.7	18.6	0.6	3.9	11.6	2.3	0.3	311
12.00	39.4	28.4	32.1	42.5	28.9	28.6	2.86	9.3				56.2	29.2	0.0	2.8	9.0	2.8	0.0	353
14.00	37.4	31.6	31.0	41.7	32.1	26.2	2.57					59.3	29.1	0.0	2.6	8.5	0.6	0.0	351
15.00	39.6	29.4	31.0	43.1	29.9	27.1	2.88	9.2				62.5	23.7	0.0	2.4	10.3	1.1	0.0	379
16.00	38.1	32.0	29.9	42.6	28.9	28.4	2.71	9.1				63.5	22.4	0.0	5.1	8.8	0.3	0.0	375
17.00	39.5	30.5	30.0	42.8	32.5	24.7	2.41	9.2				63.8	24.7	0.3	2.6	7.9	0.7	0.0	304
18.00	37.6	32.1	30.4	42.3	32.3	25.3	2.40	10.3				61.7	24.1	0.6	3.5	8.9	1.3	0.3	316
19.00	41.0	28.3	30.8	44.6	29.2	26.3	3.03	9.8				60.8	19.1	1.3	4.4	12.4	1.8	0.3	388
20.00	38.4	31.3	30.3	43.1	31.7	25.2	2.63	10.2				59.8	30.3	0.0	3.2	9.0	1.5	0.3	343
21.00	40.2	28.7	31.1	43.6	29.8	26.6	2.59	9.6				60.6	27.4	0.0	2.5	9.2	0.3	0.3	325
22.00	37.7	30.3	32.0	41.8	30.0	28.1	2.69	9.3				63.4	22.6	0.6	3.5	8.9	1.0	0.3	314
23.00	37.7	31.5	30.9	41.8	32.4	25.8	2.98	9.5				57.8	25.5	1.1	4.3	9.4	1.3	0.3	372
24.00	39.8	30.5	29.8	42.7	33.0	24.3	3.50	9.5				60.3	22.1	0.7	4.3	10.2	2.1	0.2	421
25.00	38.5	31.0	30.5	42.5	32.8	24.7	3.03	11.2				58.0	27.5	0.3	2.5	11.0	1.0	0.3	400
29.00	35.7	31.5	32.8	38.5	33.8	27.8	1.72	10.4				62.1	28.0	0.0	2.9	7.0	0.0	0.0	243
30.00	34.7	33.4	31.9	38.7	34.5	26.8	2.71	10.3				61.1	27.8	0.6	2.0	6.8	1.7	0.0	352
31.00	35.0	31.5	33.5	37.9	33.8	28.3	2.46	10.6				60.3	26.8	0.0	1.6	9.0	1.9	0.3	310
32.00	35.8	31.8	32.3	39.7	32.5	27.8	2.75	10.2				64.1	24.0	0.0	2.8	7.2	1.4	0.3	362
33.00	33.2	32.9	33.9	35.8	35.4	28.8	2.08	11.1				67.8	18.1	0.5	2.6	7.9	2.9	0.3	382
34.00	35.9	34.7	29.4	40.1	35.2	24.6	2.97	11.5				58.5	20.4	0.0	5.6	12.7	2.6	0.3	378
35.00	33.0	34.6	32.3	36.0	37.0	27.0	2.27	11.5				56.3	32.9	0.3	2.0	6.4	2.7	0.0	297
36.00	47.8	24.1	28.1	52.1	25.8	22.1	4.06	10.1				60.9	33.7	0.0	0.4	2.9	2.5	0.0	276
37.00	41.8	25.2	33.0	45.8	27.7	26.5	2.41	10.3				61.3	30.3	1.2	2.5	3.7	0.6	0.0	323
38.00	43.9	24.5	31.6	46.7	28.2	25.1	2.58	10.7				68.7	25.9	0.9	1.6	2.8	3.2	0.0	316
39.00	43.2	24.8	32.0	46.4	28.9	24.7	2.84	10.4				60.4	31.3	0.0	2.5	3.6	2.5	0.0	364
40.00	41.5	27.0	31.6	45.6	29.5	24.9	2.93	10.5				60.8	28.7	0.0	3.2	3.8	2.0	1.2	342
41.00	40.9	27.6	31.5	45.1	31.1	23.9	2.63	10.3				63.6	31.0	0.5	1.9	1.9	1.1	0.0	368
42.00	43.2	24.0	32.8	46.0	29.3	24.7	2.53	10.2				55.7	34.8	0.0	1.2	3.9	3.4	0.0	348
43.00	42.0	26.2	31.8	45.9	30.2	23.9	2.47	10.0				56.2	35.4	0.0	1.9	3.4	2.2	0.3	322
44.00	43.2	23.6	33.2	46.2	27.9	25.9	2.82	10.5				55.4	33.1	0.3	4.1	4.7	2.1	0.0	341
46.00	40.6	25.5	34.0	44.6	29.5	26.0	7.91	10.3				57.6	35.3	1.3	2.1	2.6	1.0	0.0	309
47.00	42.3	23.1	34.6	45.1	28.2	26.6	2.51	10.7				54.2	35.3	0.3	4.4	2.0	3.8	0.3	343
48.00	41.0	25.9	33.1	44.9	29.2	25.8	2.37	9.9				59.5	31.8	0.3	2.2	2.8	2.2	0.9	321

T42

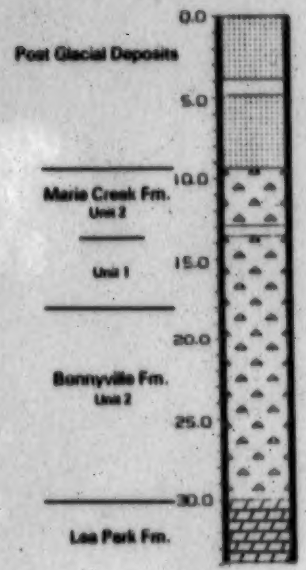
Alberta Geological Survey Testhole T 42
Location of LSD 13 Sec 5 Twp 65 Rng 3 W of 4 Mer . NTS 73L
Elevation 2030 Ft 619 M Source 1 50,000 NTS 73L/9.
Date drilled 197608.22 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	43.5	26.2	30.3	46.9	27.4	25.8	2.56	12.0				71.8	23.3	1.8	0.9	0.6	1.5	0.0	326
2.00	39.6	31.5	28.9	43.6	31.8	24.7	2.83	9.6				60.4	17.7	0.9	5.0	15.2	0.9	0.0	323
3.00	44.3	28.3	27.4	47.9	28.6	23.5	3.29	11.1				63.2	22.8	0.2	4.0	8.6	1.2	0.0	421
4.00	45.5	26.4	28.1	49.5	26.5	24.0	2.70	10.6				64.6	20.8	1.2	3.9	8.6	0.9	0.0	336
5.00	46.1	26.9	27.0	49.8	27.2	23.0	3.30	10.0				60.1	27.0	1.0	2.4	7.1	2.6	0.0	423
6.00	33.0	26.9	40.1	36.4	28.6	35.0	1.89	12.0				63.5	27.8	1.6	3.5	2.0	1.2	0.4	255
7.00	38.4	26.6	35.0	41.6	28.0	30.4	2.59	11.2				67.8	21.4	0.3	4.3	2.9	2.3	1.1	351
8.00	48.4	28.6	23.0	52.5	29.4	18.0	3.51	10.6				63.2	25.3	0.9	4.1	4.6	1.8	0.0	438
9.00	48.7	27.8	23.5	52.4	29.8	17.8	3.24	9.8				58.5	30.4	0.2	4.5	4.7	1.6	0.0	424
10.00	49.1	27.3	23.5	53.3	28.7	18.0	3.53	9.2				59.8	27.7	0.5	4.9	3.5	3.0	0.2	430
11.00	39.5	28.5	32.0	43.1	33.2	23.6	3.03	10.0				72.8	24.1	0.8	0.8	1.6	0.0	0.0	382
12.00	26.2	31.8	42.0	28.9	41.6	29.5	1.59	12.4				65.4	29.8	1.9	1.9	1.0	0.0	0.0	208
13.00	22.0	36.4	41.7	24.7	47.2	28.1	1.11	14.1				64.2	29.6	0.6	2.5	2.5	0.6	0.0	159
14.00	25.8	35.5	38.7	29.3	43.3	27.4	1.04	14.5				70.9	24.8	0.7	2.1	1.4	0.0	0.0	141
15.00	34.2	34.1	31.7	38.5	37.8	23.7	1.32	11.7				66.9	30.6	1.2	0.0	0.0	0.6	0.0	157
16.00	42.1	25.3	32.6	46.9	28.7	24.3	1.76	9.8				70.4	26.1	1.3	0.9	0.4	0.8	0.0	230
17.00	41.1	27.2	31.7	46.2	29.1	24.6	1.83	12.8				67.9	26.6	1.3	1.7	0.8	0.8	0.0	237
18.00	41.8	26.3	32.0	46.3	30.2	23.6	1.45	10.1				69.9	25.2	1.5	1.9	1.5	0.0	0.0	206
19.00	40.9	26.0	33.1	46.0	28.6	25.5	1.20	9.7				70.7	26.2	0.8	1.1	0.4	0.0	0.0	263
20.00								18.0											
21.00	26.6	42.5	31.0	35.4	40.9	23.7	0.88	11.4				56.6	30.1	2.9	0.7	1.5	0.7	0.0	136
22.00	24.5	45.5	29.9	35.3	41.5	23.2	0.80	14.0				62.0	32.7	0.0	1.8	2.7	0.0	0.0	113
25.00								12.7											
26.00	19.4	30.9	49.7	22.9	37.2	39.9	0.74	14.1				64.2	22.1	0.0	3.2	7.4	1.1	0.0	95
27.00	31.6	26.9	41.5	35.2	30.7	34.1	1.72	13.6				67.9	20.8	2.7	1.8	6.8	0.0	0.0	221
28.00	40.6	30.2	29.2	44.2	32.8	23.0	2.50	9.8				56.9	24.4	1.8	4.8	11.3	0.9	0.0	336
29.00	41.6	29.3	29.1	45.6	31.2	23.2	3.32	9.6				60.5	21.5	0.5	3.1	13.2	1.3	0.0	387
30.00	41.9	28.6	29.5	45.4	31.2	23.4	2.96	9.8				55.4	24.0	1.7	4.8	13.8	0.3	0.0	354
31.00	41.1	29.4	29.6	45.1	32.1	22.9	2.71	10.1				60.2	23.0	1.2	2.9	11.1	1.8	0.0	344
32.00	41.6	28.9	29.4	44.9	32.6	22.6	2.40	8.8				57.1	26.7	2.2	4.0	8.7	0.9	0.0	322
33.50	41.6	28.3	30.2	45.6	30.5	23.9	3.14	8.8				62.3	22.6	1.0	2.3	10.1	1.9	0.0	398
34.00	42.8	29.8	31.4	46.0	28.9	25.1	2.92	9.6				62.0	23.1	0.3	2.3	9.8	2.3	0.0	389
35.00	42.4	26.0	31.6	46.2	28.5	25.2	2.61	9.3				63.2	21.8	1.5	2.8	9.8	0.9	0.0	326
36.00	40.9	26.1	33.0	44.0	30.0	26.0	2.65	9.0				63.6	20.1	0.5	3.7	11.5	0.6	0.0	409
37.00	39.8	28.2	32.0	43.4	30.7	25.9	2.53	9.0				61.6	21.2	0.4	2.8	12.8	1.2	0.0	250

T43

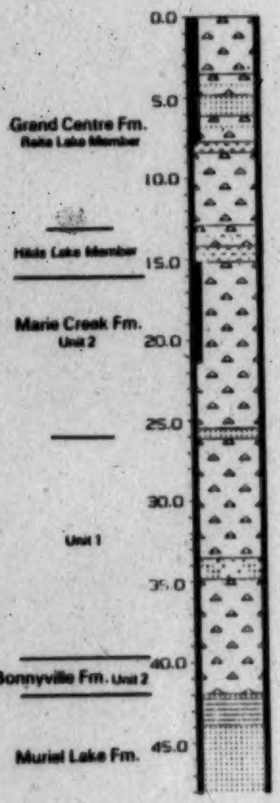
Alberta Geological Survey Testhole 1 43
Location: of LSD 16 Sec 26 ,Twp 61 Rng 7 W of 4 Mer , NTS 73L
Elevation: 1800 Ft 549 M Source: 1:50,000 NTS 73L/7
Date drilled: 197608 26 Logged by: M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
10.00	40.1	23.7	36.2	44.0	26.8	29.2	1.90	13.8				67.5	26.2	0.8	2.5	2.5	0.4	0.0	240
11.00	35.8	31.1	33.1	39.9	32.6	27.4	2.46	11.7				55.7	20.1	0.0	5.7	16.2	2.2	0.0	314
12.00	39.5	35.1	25.4	44.4	33.5	22.2	2.52	9.9				60.5	18.8	0.3	3.9	13.6	2.9	0.0	309
13.00																			
14.00	37.3	24.7	38.0	40.9	26.6	32.6	2.85	9.9				61.9	26.6	0.0	3.0	7.6	0.8	0.0	368
15.00	34.5	26.5	39.0	37.8	29.4	32.8	2.30	10.0				64.9	18.4	0.3	5.5	9.5	1.5	0.0	326
16.00	34.0	25.3	40.8	37.5	27.3	35.3	2.35	10.2				62.0	25.1	0.6	3.7	8.1	0.6	0.0	326
17.00	28.8	29.4	41.8	32.1	33.8	34.2	1.84	12.1				59.3	24.5	0.8	5.5	8.5	1.2	0.0	236
18.00	53.0	27.7	19.3	56.7	26.5	16.9	3.52	8.3				57.3	33.1	1.5	3.5	2.2	2.2	0.0	450
19.00	52.5	28.2	19.2	56.2	27.5	16.2	3.02	8.4				58.3	33.2	0.5	5.7	1.5	0.4	0.0	385
20.00	54.0	27.9	18.1	57.7	28.6	13.7	3.70					60.3	29.5	2.1	4.5	1.5	1.7	0.0	456
21.00	54.1	27.1	18.8	58.0	27.1	14.9	3.49	8.5				58.2	34.4	1.1	3.2	1.3	1.5	0.0	464
22.00	53.5	27.3	19.2	57.2	27.2	15.6	3.57	9.3				54.2	35.1	1.1	5.6	1.9	0.7	0.0	430
23.00	51.4	26.7	21.9	55.1	26.3	18.5	2.77	9.7				58.0	32.4	0.3	3.7	1.9	3.3	0.0	376
24.00	52.3	25.7	22.0	55.8	26.8	17.4	3.35	8.9				55.4	33.3	1.2	3.5	4.2	2.6	0.0	426
25.00	52.3	27.5	20.2	55.9	27.0	17.0	3.31	8.8				59.4	31.9	0.5	3.7	2.7	1.6	0.0	407
26.00	53.1	26.1	20.8	56.7	26.0	17.2	3.19	9.4				54.9	34.7	1.0	4.2	1.7	3.6	0.0	407
27.00	45.3	23.1	31.6	48.7	23.7	27.6	2.60	12.2				59.3	30.2	0.6	3.7	3.7	2.4	0.0	295
28.00	32.8	18.8	48.3	35.3	22.8	41.9	1.72	14.0				62.9	27.2	0.0	1.8	4.5	3.6	0.0	324
29.00	56.0	30.0	14.0	59.8	28.9	11.3	2.95	8.8				65.0	26.8	0.5	3.2	2.4	2.1	0.0	377

T44

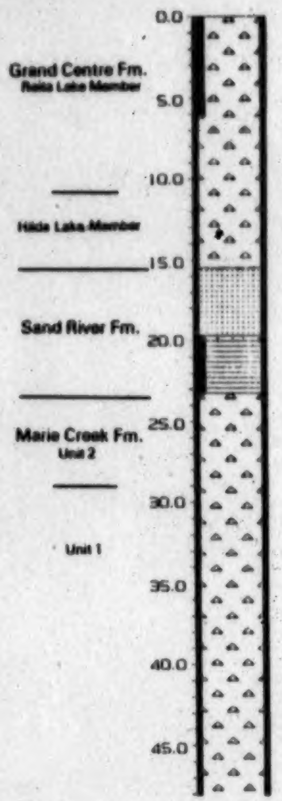
Alberta Geological Survey Testhole T 44
Location: of LSD 14 Sec 24 Twp 61 Rng 6 W of 4 Mer . NTS 73L
Elevation: 1825 Ft 556 M Source: 1:50,000 NTS 73L/7
Date drilled: 197608.27 Logged by: M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)					
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	37.0	23.0	40.0	41.0	24.0	35.0	1.40	13.8				72.4	21.0	1.9	0.0	0.0	4.7	0.0	214
2.00	38.0	24.0	39.0	40.0	27.0	33.0	1.70	13.1				69.1	20.6	3.1	3.6	3.6	0.0	0.0	194
3.00	43.0	23.0	34.0	46.0	25.0	28.0	1.70	10.4				68.5	27.2	0.0	1.4	1.9	0.9	0.0	213
4.00								10.3											
6.00								10.4											
7.00	42.0	24.0	33.0	47.0	25.0	28.0	1.90	10.1				68.7	26.5	0.4	1.2	2.8	0.4	0.0	249
8.00	40.0	26.0	34.0	44.0	28.0	28.0	1.60	9.7				75.1	23.5	0.0	0.5	0.5	0.0	0.5	213
9.00								9.7											
10.00	37.0	27.0	37.0	41.0	29.0	31.0	1.40	10.1				64.4	30.3	1.1	1.1	2.1	1.1	0.0	188
11.00								10.4											
12.00	23.0	26.0	52.0	25.0	33.0	42.0	0.71	13.4				67.3	28.0	0.9	0.9	1.9	0.9	0.0	107
13.00								13.3											
14.00	31.0	34.0	35.0	36.0	35.0	30.0	1.10	11.4				63.1	24.8	0.0	2.7	9.4	0.0	0.0	149
15.00	33.0	26.0	42.0	35.0	31.0	34.0	2.10	11.7				61.5	20.9	0.0	2.9	13.7	1.1	0.0	278
16.00	30.0	29.0	41.0	33.0	33.0	33.0	2.50	9.4				61.6	17.1	0.0	4.6	16.1	0.6	0.0	328
17.00	37.0	31.0	32.0	40.0	33.0	27.0	2.50	9.9				50.0	15.6	0.0	7.2	24.5	2.7	0.0	334
18.00	39.0	32.0	29.0	43.0	34.0	23.0	2.80	9.9				61.5	15.0	0.0	5.6	14.7	3.2	0.0	374
19.00	40.0	31.0	29.0	43.0	33.0	24.0	3.10	10.4				55.8	18.9	0.8	3.5	19.3	1.9	0.0	373
20.00	40.0	33.0	28.0	44.0	33.0	23.0	2.60	9.8				55.8	19.8	0.0	4.9	15.7	3.5	0.3	344
21.00	41.0	32.0	27.0	45.0	33.0	22.0	2.80	10.3				60.4	19.5	0.0	3.3	14.0	2.4	0.3	364
22.00	39.0	35.0	26.0	44.0	34.0	22.0	3.00	9.7				63.7	17.1	0.0	5.3	12.5	1.1	0.3	375
23.00	40.0	33.0	27.0	44.0	34.0	23.0	2.80	8.9				67.3	15.6	0.3	3.8	11.3	1.7	0.0	364
24.00	41.0	32.0	27.0	46.0	32.0	23.0	3.60	8.6				64.2	19.8	0.7	2.1	10.5	2.3	0.2	428
25.00	40.0	27.0	32.0	43.0	29.0	29.0	3.10					69.3	16.6	0.2	2.5	9.5	1.4	0.0	398
26.00	34.0	32.0	34.0	38.0	33.0	29.0	2.60	8.9				64.9	23.4	0.0	3.1	7.9	0.7	0.0	291
27.00	35.0	25.0	40.0	37.0	27.0	35.0	2.30	9.6				63.3	24.0	1.7	4.3	6.0	0.6	0.0	300
28.00	33.0	28.0	39.0	37.0	31.0	32.0	2.40	9.8				67.5	21.7	0.3	2.3	7.5	0.3	0.3	308
29.00	35.0	28.0	37.0	38.0	31.0	31.0	2.30					69.4	21.8	1.0	1.4	5.4	0.9	0.0	294
30.00	33.0	28.0	39.0	36.0	32.0	33.0	2.20	10.1				67.6	21.5	0.3	4.1	5.5	0.3	0.3	293
31.00	33.0	28.0	39.0	36.0	31.0	33.0	2.60	10.4				64.6	21.6	0.0	1.2	11.4	0.9	0.3	333
32.00	32.0	25.0	43.0	34.0	30.0	36.0	2.70	10.9				68.4	22.4	0.3	2.1	5.9	0.6	0.0	339
33.50	31.0	27.0	42.0	34.0	31.0	35.0	2.70	8.9				66.9	24.1	0.3	1.4	6.7	0.6	0.0	344
35.00	40.0	26.0	35.0	43.0	29.0	29.0	2.60					65.8	27.4	0.0	1.2	5.2	0.3	0.0	328
36.50	43.0	25.0	33.0	46.0	27.0	27.0	2.40	9.1				65.4	25.4	0.3	3.1	4.8	0.9	0.0	350
39.50	49.0	29.0	22.0	52.0	30.0	18.0	2.40					56.2	35.9	2.4	0.0	3.8	0.3	0.3	292
40.00	45.0	28.0	27.0	49.0	29.0	22.0	1.40	7.5				57.4	36.8	2.1	0.5	0.0	1.5	0.5	190
41.00	45.0	24.0	31.0	48.0	27.0	25.0	1.50	9.8				59.0	32.2	2.4	2.9	2.9	0.0	0.0	206
42.50								15.0											
43.00								16.6											

T45

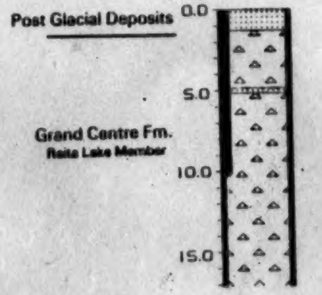
Alberta Geological Survey Testhole T 45
Location: of LSD 1 Sec 8 Twp 60 Rng 7 W of 4 Mer . NTS 73L
Elevation 2000 Ft 610 M Source 1:50,000 NTS 73L/2
Date drilled 197608 28 Logged by M. FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								9.7											
2.00	41.5	40.3	18.2	47.0	39.4	13.7	2.41	8.8	50.0	20.8	0.17	59.3	20.7	0.0	5.2	13.1	1.4	0.0	290
3.00	34.1	31.3	34.6	38.0	33.2	28.8	1.72	10.9	25.3	10.6	0.28	66.7	24.6	0.8	3.6	2.8	1.6	0.0	293
4.00	39.4	22.7	37.8	42.6	25.2	32.1	2.03	13.0	22.8	9.5	0.25	69.5	23.0	2.3	1.9	2.8	0.5	0.0	213
5.00	35.0	27.9	37.1	38.7	30.1	31.2	1.66	12.3	22.4	9.4	0.36	70.5	21.9	0.4	3.4	2.6	1.2	0.0	234
6.00	30.6	28.0	41.4	34.3	29.8	35.8	1.35	11.9	22.5	9.5	0.31	66.5	26.2	0.0	3.0	3.0	0.8	0.0	164
7.00	30.7	27.9	41.4	34.5	30.0	35.5	1.23	11.9	23.8	10.0	0.28	63.0	26.1	1.2	2.5	2.5	4.4	0.0	157
8.00	38.4	28.3	33.3	42.8	29.3	27.9	1.31	11.1	27.6	11.5	0.23	69.6	25.6	0.6	2.4	1.2	0.6	0.0	168
9.00	36.9	27.3	35.7	41.1	28.9	29.9	1.18	11.1	27.3	11.4	0.25	70.8	23.2	1.3	2.0	2.6	0.0	0.0	151
10.00	32.9	28.1	39.0	36.6	30.6	32.7	1.10	10.6	26.9	11.3	0.24	75.9	18.4	0.0	0.7	2.1	2.8	0.0	141
11.00	26.8	25.3	48.0	30.0	29.9	40.1	0.89	12.5	27.9	11.6	0.22	73.0	23.5	0.9	1.7	0.0	0.9	0.0	115
12.00	28.8	26.0	45.2	32.2	29.9	37.9	1.16	11.4	27.7	11.6	0.27	67.8	24.6	1.7	1.7	2.5	1.7	0.0	118
13.00	21.5	29.5	49.0	24.6	34.8	40.7	0.55	11.8	30.6	12.7	0.19	72.8	21.0	1.2	2.5	1.2	1.2	0.0	81
14.00	29.9	23.7	46.4	33.2	28.5	38.3	1.25	11.6	26.4	11.0	0.17	77.8	18.4	1.2	0.0	0.6	1.2	0.0	162
15.00	24.3	23.1	52.6	27.4	28.9	43.8	0.68	11.7	24.9	10.4	0.21	70.7	19.0	0.0	1.7	8.6	0.0	0.0	58
20.00								19.8											
21.00								18.5											
22.00								20.0											
23.00								21.2											
24.00	37.6	32.4	29.9	41.6	34.2	24.2	2.81	10.5	44.9	18.7	0.14	57.3	19.3	0.6	4.0	17.0	1.7	0.0	347
25.00	36.9	32.3	30.8	41.1	34.0	24.9	2.72	10.6				60.1	19.5	0.3	5.0	12.9	2.1	0.0	318
26.00	36.9	32.7	30.3	41.0	34.6	24.4	2.62	10.9	46.7	19.4	0.15	56.4	20.2	0.6	1.0	15.1	2.5	0.0	312
27.00	36.4	33.8	29.9	40.5	35.7	23.8	2.70	10.5				61.4	18.4	1.2	4.1	12.9	2.1	0.0	342
28.00	35.6	34.4	30.0	39.5	36.3	24.2	2.75	10.5	41.8	17.4	0.16	59.3	21.9	0.3	4.1	10.4	3.6	0.0	337
29.00	33.1	31.2	35.6	36.7	34.7	28.6	2.22	10.8				69.5	16.5	0.7	2.8	8.4	2.0	0.0	285
30.00	35.2	29.1	35.7	38.7	32.8	28.5	2.42	10.7	35.5	14.8	0.19	61.7	22.9	0.3	4.4	6.2	1.7	0.0	292
31.00	33.4	31.5	35.1	37.1	35.6	27.3	2.35	11.0				66.3	19.0	1.3	2.7	8.5	1.7	0.0	294
32.00	33.4	31.3	35.3	36.9	34.3	28.8	2.25	11.1	35.1	14.6	0.16	60.3	25.1	1.4	1.7	9.7	1.7	0.0	287
33.50	32.9	30.9	36.2	36.5	34.7	28.8	2.35					61.3	25.3	1.0	2.8	5.6	3.8	0.0	284
34.00	26.6	33.5	39.8	30.4	37.5	32.1	2.12	11.2	41.9	17.4	0.16	63.2	20.1	0.7	3.3	10.8	1.8	0.0	269
35.00	31.0	29.4	39.5	34.4	33.5	32.1	2.31	10.6				60.7	22.7	0.3	4.1	10.0	2.0	0.0	290
36.50	32.5	29.0	38.5	36.2	32.9	30.9	2.07	10.5	35.8	14.9	0.19	66.2	23.3	0.7	3.0	3.7	2.3	0.0	266
37.00	19.6	26.4	54.0	22.4	32.8	44.8	1.07	12.8	32.4	13.5	0.21	64.9	26.3	0.7	2.0	4.0	1.3	0.0	148
38.00	15.1	28.6	56.3	17.6	36.3	46.1	0.80	13.2	31.9	13.3	0.17	70.0	18.2	0.9	0.9	7.3	2.7	0.0	110
39.50	27.0	29.8	43.2	30.4	34.6	35.0	1.76	11.5				70.0	16.7	0.4	1.7	11.0	2.2	0.0	228
40.00	33.1	28.6	38.3	36.6	32.6	30.7	2.61	11.1	35.2	14.7	0.22	69.1	19.9	0.3	2.5	6.9	1.2	0.0	317
41.00	31.6	29.8	38.6	34.9	33.3	31.8	1.94	11.3	34.1	14.2	0.18	65.0	18.7	0.4	5.0	10.1	0.8	0.0	257
42.50	31.7	30.3	37.9	35.3	33.6	31.1	2.22	10.9	35.6	14.8	0.17	69.5	21.5	0.3	1.0	6.4	1.3	0.0	298
43.00	32.3	28.7	39.0	35.6	31.9	32.5	2.13	10.6	36.7	15.3	0.22	65.6	24.5	0.7	1.5	7.3	0.4	0.0	273
44.00																			
45.00	32.3	30.7	37.0	35.8	33.9	30.3	2.47	13.8	36.9	15.4	0.22	65.2	24.4	0.7	1.7	6.7	0.6	0.0	299
46.00	31.5	30.3	38.2	34.9	33.8	31.3	2.00	10.9	36.8	15.4	0.24	62.4	26.9	0.0	5.1	4.3	0.8	0.0	253
47.00	27.6	29.3	43.1	30.9	33.4	35.7	1.74	12.2	35.0	14.6	0.21	58.4	22.5	0.0	5.2	11.7	2.2	0.0	231

T46

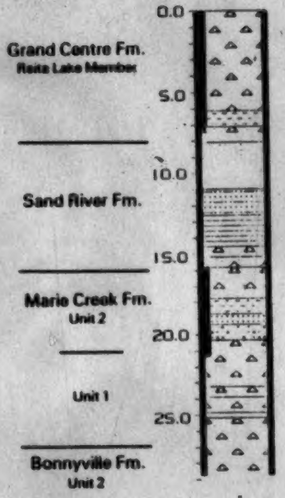
Alberta Geological Survey Testhole   I 46
Location: of LSD 16 Sec 23 Twp 60 Rng 6 W of 4 Mer . NTS: 73L
Elevation: 2020 Ft   616 M Source 1:50,000 NTS 73L/2
Date drilled: 197608 29 Logged by: M FENION



DEPTH (M)	TEXTURE (%) SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00	33.8	25.3	40.9	37.6	26.6	35.7	1.50	13.5				65.0	32.0	2.5	0.0	0.0	0.5	0.0	203
3.00	35.3	27.7	37.0	38.5	29.8	31.7	1.28	12.1				66.1	27.9	1.8	0.0	4.2	0.0	0.0	165
4.00	35.0	27.9	37.1	39.3	28.8	31.9	1.58	13.2				67.2	22.4	0.4	1.7	4.3	3.9	0.0	202
5.00	36.7	26.1	37.2	40.0	28.6	31.3	1.64	13.1											
6.00	44.6	25.8	29.6	49.6	26.5	23.9	2.35	11.2				67.1	26.8	0.7	2.1	3.2	0.3	0.0	280
7.00	35.5	37.8	26.6	40.5	37.9	21.6	1.33	10.2				70.0	24.0	0.0	3.0	1.8	0.6	0.0	167
8.00	35.4	36.0	28.7	41.0	36.0	22.9	1.43	9.8				68.9	26.7	2.2	0.0	1.1	1.1	0.0	180
9.00	41.5	23.5	35.0	44.6	26.4	29.0	1.55	10.8											
10.00	38.4	26.0	35.6	42.9	28.2	28.9	1.62	10.5				71.7	23.6	0.5	0.9	2.8	0.5	0.0	212
11.00	39.4	25.8	34.8	42.7	28.1	29.2	1.76	10.6											
12.00	38.1	26.8	35.2	42.5	29.0	28.5	1.38	10.3				72.2	21.1	0.5	2.6	4.1	0.0	0.0	194
13.00	39.3	26.4	34.3	42.9	29.7	27.4	1.55	10.7											
14.00	36.9	26.0	37.1	41.2	30.3	28.5	1.60	10.4				62.0	33.0	1.3	2.2	0.9	0.4	0.0	224
15.00	38.6	25.4	36.0	41.8	28.3	29.9	1.53	10.5											
16.00	35.6	26.5	38.0	39.7	29.0	31.3	1.50	11.1				64.8	31.2	0.0	1.0	2.5	0.5	0.0	202
17.00	33.9	28.2	37.8	37.4	32.4	30.2	1.48	10.3											

T47

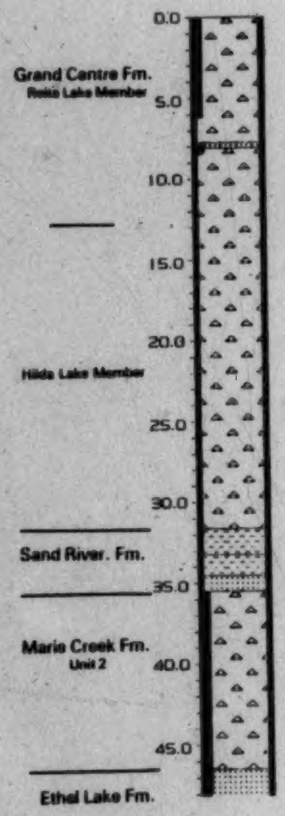
Alberta Geological Survey Testhole T 47
Location: of LSD 12 Sec 36 Twp 60 Rng 6 W of 4 Mer ; NIS: 73L
Elevation: 1855 Ft 566 M Source: 1 50,000 NIS 73L/2
Date drilled: 197608 24 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT OSS	LST	DST	LOC	OTH	N
1.00	36.6	25.2	38.3	40.4	25.9	33.6	1.38	11.7											
2.00	37.0	23.8	39.2	40.0	26.2	33.9	1.45	8.9				57.8	37.5	0.5	0.0	3.6	0.5	0.0	192
3.00	35.4	28.0	36.6	40.3	28.6	31.0	1.61	13.0											
4.00	36.7	28.0	35.3	40.2	29.9	29.9	1.49	12.8				65.0	25.0	0.5	1.5	7.5	1.0	0.0	200
5.00	32.2	31.9	35.8	37.5	32.1	30.3	1.11	13.7											
6.00	4.3	36.7	59.0	6.3	43.3	50.4	0.12	16.9				54.5	0.0	18.2	9.1	0.0	18.2	0.0	11
7.00	20.1	37.0	42.9	23.2	45.1	31.7	0.70	11.7											
8.00	40.2	26.1	33.6	43.6	29.1	27.4	1.45	9.6				73.0	21.3	1.7	0.6	3.9	0.0	0.0	178
11.00								12.6											
12.00								13.9											
13.00								15.4											
14.00								15.6											
15.00	17.4	23.9	58.7	19.9	37.6	42.5	1.11	14.6				53.6	21.4	0.3	6.9	17.1	1.6	0.0	304
16.00	31.9	34.9	33.2	34.7	38.6	26.7	2.52	12.0											
17.00	31.6	43.5	24.9	35.0	45.7	19.3	2.04	10.6											
17.50	40.3	38.2	21.5	43.0	40.5	16.5	2.67	10.2				54.8	24.8	0.0	3.1	14.0	3.1	0.0	350
19.00																			
20.00																			
21.00	30.3	33.2	36.5	33.8	36.0	30.3	1.97	10.8				59.7	28.4	0.4	1.6	9.3	0.8	0.0	246
22.00	27.6	32.6	39.8	30.2	37.5	32.3	1.70												
23.00	24.6	34.9	40.5	27.9	38.4	33.7	1.80					62.8	27.8	0.0	2.7	4.9	1.8	0.0	223
24.00	6.3	37.0	56.7	7.8	47.0	45.2	0.27	15.9											
25.00	29.8	30.8	39.4	32.9	34.7	32.4	2.06					63.4	27.2	0.0	3.2	6.1	0.7	0.0	279
26.00	25.3	33.3	41.5	28.0	38.3	33.7	1.95	10.4				57.9	31.6	0.0	3.6	6.1	0.8	0.0	247
27.00	41.1	33.9	25.0	46.6	33.8	19.6	1.94	10.1				56.3	37.1	0.0	3.3	2.8	0.4	0.0	245
28.00	38.3	28.0	33.7	41.2	33.5	25.3	1.86	9.8				47.8	42.7	1.5	5.1	2.0	0.8	0.0	255

T48

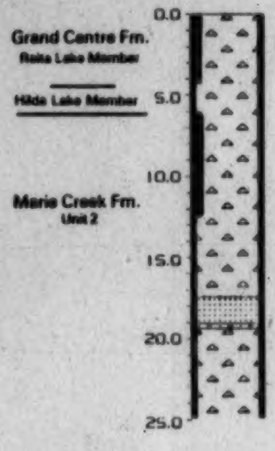
Alberta Geological Survey Testhole: T 48
Location of LSD 4 Sec 28 Twp 60 Rng 4 W of 4 Mer. NTS: 73L
Elevation 1950 ft 595 M Source: 1:50,000 NTS 73L/2
Date drilled: 197608 30 Logged by: M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METH	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	35.4	24.9	39.6	39.5	26.0	34.5	1.38	11.7	7.6	3.3	1.28	69.7	27.4	1.7	0.0	0.0	1.1	0.0	175
2.00	36.0	28.1	35.9	38.5	30.9	29.6	1.33	11.3	32.7	13.8	0.48	67.9	25.5	2.2	1.6	2.2	0.5	0.0	184
3.00	36.3	28.6	35.1	40.5	29.0	30.5	1.73	12.1	30.4	12.7	0.29	70.5	24.2	1.8	1.3	1.8	0.4	0.0	227
4.00	38.7	28.2	33.1	42.5	29.6	27.9	1.73	12.6	31.5	13.2	0.28	68.7	25.1	0.9	0.5	2.4	2.4	0.0	211
5.00	34.8	27.9	37.3	38.6	29.5	31.9	1.45	13.3	31.3	13.1	0.26	69.8	24.3	1.0	1.5	3.0	0.0	0.5	202
6.00	37.5	27.8	34.7	42.0	29.0	29.1	1.48	13.4	33.3	13.9	0.27	70.3	28.2	1.0	0.5	0.0	0.0	0.0	195
7.00	34.0	28.4	37.6	38.2	29.9	31.9	1.37	13.3	36.2	15.1	0.26	65.9	28.1	0.0	2.2	3.2	0.5	0.0	185
8.00								9.8											
9.00	36.1	30.4	33.5	41.8	30.7	27.6	1.64	10.6	28.0	11.7	0.24	72.3	23.3	0.0	1.0	3.5	0.0	0.0	202
10.00	35.4	29.7	35.0	39.6	31.5	28.9	1.52	12.3	26.2	10.9	0.22	78.4	18.4	0.5	2.2	0.0	0.5	0.0	185
11.00	28.2	26.1	45.7	30.8	32.6	36.5	0.73	12.5	28.3	11.8	0.27	75.7	21.4	1.9	1.0	0.0	0.0	0.0	103
12.00	46.2	23.4	30.4	49.7	24.9	25.4	1.94	9.9	21.8	9.1	0.14	79.1	19.8	1.1	0.0	0.0	0.0	0.0	273
13.00								15.9											
14.00								16.1											
15.00								13.7											
16.00								13.4											
17.00								16.0											
18.00	24.0	26.5	49.5	26.9	33.5	39.7	0.72	14.1	28.1	11.7	0.22	77.3	18.2	2.3	0.0	2.3	0.0	0.0	88
19.00	25.9	27.6	46.5	28.8	33.0	38.2	0.82	13.8	26.0	10.8	0.19	76.7	19.8	1.7	0.9	0.9	0.0	0.0	116
20.00	22.5	26.8	50.7	25.2	34.0	40.8	0.72	14.2	28.7	12.0	0.21	70.8	24.0	2.1	2.1	1.0	0.0	0.0	96
21.00	24.1	26.4	49.5	26.6	32.2	41.2	0.69	14.0	25.9	10.8	0.23	77.9	16.3	2.9	2.9	0.0	0.0	0.0	104
22.00	24.8	27.0	48.2	27.8	33.2	38.9	0.75	14.4	28.2	11.8	0.32	79.6	19.4	0.0	0.0	0.0	1.1	0.0	93
23.00	15.8	25.7	58.5	17.7	33.7	48.6	0.62	16.0	27.1	11.4	0.34	81.2	17.4	0.0	1.4	0.0	0.0	0.0	69
24.00	23.8	28.5	47.7	26.7	35.2	38.1	0.75	13.5	28.4	11.9	0.30	71.7	21.7	1.9	1.9	0.0	2.8	0.0	106
25.00	18.5	23.3	58.2	20.3	30.5	49.3	0.53	13.5	26.7	11.2	0.32	81.8	14.3	0.0	2.6	0.0	0.0	1.3	77
26.00	23.9	26.6	49.5	26.6	33.3	40.0	0.70	13.7	29.6	12.4	0.24	75.8	20.0	0.0	2.1	1.1	0.0	1.1	95
27.00	25.6	27.1	47.3	28.6	34.0	37.4	0.99	13.1	29.4	12.3	0.25	75.2	18.7	2.6	0.0	2.6	0.0	0.0	117
28.00	24.4	26.5	49.1	27.2	34.7	38.1	0.75	13.8	27.8	11.7	0.27	77.0	21.0	0.0	0.0	2.0	0.0	0.0	100
29.00	22.8	24.8	52.4	25.5	32.4	42.1	0.70	14.5	26.8	11.2	0.27	78.6	18.8	0.9	1.7	0.0	0.0	0.0	117
30.00	23.9	25.8	50.3	26.4	34.3	39.3	0.91	13.4	28.2	11.8	0.21	75.3	20.4	1.1	1.1	1.1	1.1	0.0	93
31.00	21.4	29.6	49.0	27.0	33.8	39.2	0.82	13.3	27.6	11.5	0.23	71.3	22.2	0.9	3.7	0.0	0.0	1.9	108
32.00								20.0											
33.00								14.2											
35.00	37.2	32.0	30.9	40.9	35.4	23.7	2.16	9.8	49.5	20.6	0.19	56.3	21.1	0.4	5.7	14.0	2.2	0.4	279
36.50	39.8	36.1	24.1	45.1	35.2	19.7	2.54	10.0	45.6	19.0	0.17	54.5	25.4	0.0	4.3	11.8	3.7	0.3	323
37.00	42.0	35.5	22.5	47.0	35.6	17.4	2.64	9.7	48.1	20.0	0.12	61.6	23.8	0.0	4.8	9.2	0.6	0.0	357
38.00	41.0	34.8	24.2	45.3	35.3	19.4	2.93		46.8	19.5	0.16	57.1	23.2	0.0	4.5	13.3	1.9	0.0	375
39.50	39.8	38.6	21.6	44.7	39.1	16.2	2.76	11.2	50.5	21.0	0.13	52.7	25.4	0.0	6.5	13.6	1.8	0.0	338
40.00	33.0	46.4	20.6	37.1	47.5	15.4	2.09	11.9	52.7	21.9	0.10	53.0	21.4	0.0	5.6	17.9	1.7	0.0	234
41.00	33.4	44.5	22.2	35.0	48.7	16.3	6.38	8.6	50.6	21.0	0.13	59.4	17.6	0.0	7.9	14.0	0.7	0.0	278
42.50	35.2	39.3	25.5	38.5	42.9	18.7	2.22	9.1	47.5	19.7	0.12	64.2	21.4	0.0	3.2	10.2	1.1	0.0	285
43.00	33.8	38.4	27.7	38.5	41.5	20.0	2.60	9.1	45.6	19.0	0.19	60.1	22.1	0.0	2.7	13.0	1.8	0.0	331
44.00	37.4	34.7	27.9	41.7	36.5	21.8	2.52	7.8	41.6	17.3	0.13	59.0	23.5	0.3	4.3	12.3	0.3	0.0	324
45.00	38.6	35.4	26.0	42.6	38.6	18.9	2.16	8.8	46.0	19.1	0.17	54.4	23.5	0.3	4.4	16.7	0.7	0.0	294
46.00																			
47.00																			

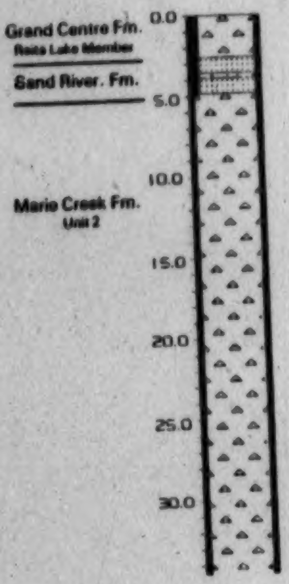
T49

Alberta Geological Survey Testhole: T 49
Location of LSD 16 Sec 12 Twp 61 Rng 5 W of 4 Mer , NTS 73L
Elevation 1805 Ft 550 M Source 1:50,000 NTS 73L/7
Date drilled 197706 24 Logged by M. FENTON



DEPTH (M)	TEXTURE (%) SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	37.9	25.7	36.4	42.0	27.2	30.8	1.64	14.5				69.0	26.4	0.0	2.2	2.2	0.0	0.0	223
2.00	38.4	25.7	35.9	41.9	28.4	29.7	1.75	13.1				69.8	16.8	1.5	2.0	4.9	1.0	1.5	202
3.00	41.0	25.5	33.5	45.3	26.4	28.3	1.89	14.0				70.5	24.5	0.0	0.8	3.3	0.8	0.0	241
4.00	39.9	24.6	35.5	43.2	27.0	29.7	1.54	13.7				74.2	19.2	0.5	1.4	4.2	0.5	0.0	213
5.00	32.5	25.0	42.5	36.2	27.8	36.0	1.61	16.2				78.1	16.5	0.0	1.4	3.4	0.5	0.0	206
6.00	21.7	26.2	52.0	24.3	35.0	40.6	1.14	13.7				69.1	19.5	0.0	3.3	8.0	0.0	0.0	149
7.00	42.5	34.2	23.3	47.2	34.5	18.3	3.29	10.3				61.4	17.9	0.2	4.1	14.0	1.9	0.2	386
8.00	39.7	35.8	24.5	44.6	36.3	19.0	3.10	10.7				52.2	18.4	0.0	4.8	22.5	1.7	0.2	391
9.00	41.8	35.5	22.8	46.3	35.9	17.8	3.15	10.5				60.4	16.3	0.2	5.3	15.3	2.2	0.0	392
10.00	42.1	36.7	21.3	46.0	37.6	16.4	3.25	9.9				60.0	22.1	0.2	6.3	10.3	1.0	0.0	398
11.00	40.9	39.5	19.6	48.3	37.7	14.0	3.37	9.3				58.9	18.0	0.2	3.7	16.1	2.6	0.5	428
12.00	43.5	35.8	20.7	49.6	34.8	15.6	3.13	9.8				61.5	21.5	0.5	3.9	11.0	1.6	0.0	382
13.00	39.9	37.8	22.3	46.1	37.3	16.5	2.70	8.6				59.3	18.1	0.0	6.7	14.5	1.1	0.0	359
14.00	44.0	33.9	22.1	49.1	34.2	16.7	4.48					61.0	14.6	0.2	2.3	20.3	1.4	0.0	513
15.00	43.8	35.1	21.0	50.5	34.5	15.0	5.19	6.8				59.2	20.8	0.0	5.3	13.5	1.0	0.0	605
16.00	41.0	40.3	18.7	47.7	38.4	13.9	3.25	8.1				59.6	18.7	0.5	4.2	14.8	0.8	0.5	384
17.00	40.3	40.7	19.0	47.7	39.2	13.1	2.93	6.9				61.6	22.7	0.0	2.7	12.1	0.0	0.0	255
19.00								14.9											
20.00	34.4	48.3	17.2	42.2	45.2	12.6	2.11	12.0				58.4	18.2	0.3	2.9	18.2	1.6	0.3	373
22.00	36.7	31.3	31.9	41.0	34.8	24.2	2.58	8.7				65.3	24.2	0.6	2.4	7.2	0.3	0.0	334
23.00	47.2	32.8	20.0	52.6	32.6	14.9	3.39	8.1				63.2	26.0	0.5	3.4	6.4	0.5	0.0	408
24.00	47.2	32.4	20.5	52.8	31.9	15.3	3.44	8.6				65.9	24.3	0.0	3.0	6.0	0.5	0.0	399
26.00	43.1	32.0	24.9	48.0	32.6	19.4	2.76	8.8				59.4	26.7	0.8	3.5	9.2	0.3	0.0	370

T50



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Alberta Geological Survey Testhole    1 50                                   NTS 73L
Location:       of LSD 16 Sec 10 Twp  58 Rng  5 W of 4 Mer .
Elevation   2115 Ft      645 M   Source  1 50,000 NTS 73L/2
Date drilled    197609 10  Logged by  M  FENTON

                                                                MATRIX CARBONATE              COARSE SAND LITHOLOGY (%)
                       TEXTURE (%)                                                  IGN   QTZ   QTZI   LST   DST   LOC   OTH     N
 DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD    H2O          CO2   CO3 CA/DO        METM        QSS
  (M)  >62 5um  <4um   >50um     <2um 1-2mm     (%)          (cc)  (%)

  1.00  43.4 22.9 33.7  47.3 23.3 29.4  1.62   10.8                                 73.2  23.7   1.5   0.0   0.0   1.5   0.0   198
  2.00  45.4 23.5 31.1  48.3 25.1 26.6  1.36   10.1                                 65.2  25.7   2.1   0.5   3.7   2.1   0.5   187

  6.00  45.5 28.3 26.1  50.0 30.3 19.7  2.99    9.1                                 68.5  26.7   0.3   2.1   1.6   0.6   0.3   375
  7.00  48.2 24.7 27.0  51.2 28.6 20.2  3.79    8.7                                 68.9  26.5   0.0   0.8   1.7   0.6   0.4   479
  8.00  42.9 26.8 30.3  46.8 29.8 23.4  2.55    9.5                                 60.9  31.7   0.6   3.1   1.5   1.8   0.3   322
  9.00  43.5 25.8 30.7  46.5 29.7 23.8  2.64    9.4                                 54.6  34.5   0.0   5.3   2.3   1.3   0.8   359
 10.00  44.7 25.5 29.7  48.7 28.4 22.8  2.63   10.1                                 62.9  30.2   0.3   2.5   2.5   1.3   0.3   364
 11.00  42.7 27.0 30.3  45.6 30.8 23.6  2.51   10.7                                 63.8  26.8   0.3   3.9   3.9   0.9   0.3   332
 12.00  45.9 27.4 26.7  50.4 28.8 20.8  2.84    9.9                                 64.4  27.7   0.5   1.6   4.1   1.2   0.5   365
 13.00  43.4 26.3 30.2  46.4 30.0 23.6  2.66    9.9                                 67.9  25.8   0.9   2.4   1.5   0.9   0.0   337
 14.00  41.9 26.7 31.4  45.9 29.6 24.5  2.58    9.7                                 64.1  26.8   0.3   4.5   2.8   1.2   0.3   351
 15.00  43.6 25.4 31.0  46.4 29.2 24.4  2.70    9.9                                 62.9  27.0   0.3   3.5   3.8   1.5   0.3   340
 16.00  41.3 27.2 31.5  45.2 30.1 24.7  2.29    9.7                                 69.4  24.6   0.3   3.6   0.7   1.3   0.0   301
 17.00  43.2 25.2 31.6  46.0 29.0 25.0  2.66   10.1                                 68.4  24.8   0.3   3.7   1.7   1.2   0.0   351
 18.00  40.4 28.5 31.1  44.4 31.6 24.1  2.57    9.9                                 67.7  22.9   0.6   3.4   2.3   3.1   0.0   353
 19.00  43.3 25.2 31.5  46.3 28.7 25.0  2.38    9.8                                 70.8  23.2   0.0   3.5   1.3   0.6   0.3   315
 20.00  41.6 27.2 31.2  45.5 29.8 24.6  2.55    9.8                                 67.8  23.7   0.0   4.5   3.0   1.2   0.0   336
 21.00  43.3 25.7 31.0  46.2 29.2 24.6  2.51   10.9                                 69.0  24.1   0.3   1.8   2.7   1.8   0.3   336
 22.00  41.7 26.1 32.2  45.8 28.5 25.8  2.71   11.0                                 65.2  26.1   0.8   3.0   2.7   1.3   0.3   371
 23.00  43.0 24.1 33.0  45.7 29.1 25.3  2.28   11.0                                 64.9  25.1   0.3   3.4   3.4   1.8   0.3   319
 24.00  43.0 24.9 32.1  45.8 29.4 24.7  2.37   10.8                                 67.0  24.2   0.0   4.1   3.4   1.2   0.0   318
 25.00  41.2 26.1 32.7  45.1 29.8 25.1  2.49   11.1                                 68.3  23.3   0.0   3.2   2.9   1.5   0.6   347
 26.00  42.8 24.7 32.5  45.9 29.3 24.9  2.26   11.0                                 65.4  25.6   0.6   1.9   3.2   2.2   0.6   312
 27.00  43.0 26.4 30.5  47.2 28.7 24.1  2.32   10.6                                 65.2  28.2   0.0   2.7   2.1   1.5   0.0   333
 28.00  44.4 25.5 30.1  47.4 29.0 23.6  2.40   10.9                                 66.1  26.1   0.6   3.6   1.2   0.9   0.9   330

 32.00  42.0 27.1 30.8  45.9 29.8 24.3  2.52   11.1                                 68.0  24.5   0.3   4.0   3.2   0.0   0.0   347
 33.50  43.5 25.5 31.0  46.4 29.0 24.5  2.84   11.1                                 69.1  23.5   0.0   3.1   3.4   0.3   0.3   353
 34.00  47.9 21.6 30.4  51.6 24.4 24.1  3.12   11.1                                 63.3  28.3   0.2   2.6   4.1   0.9   0.2   417
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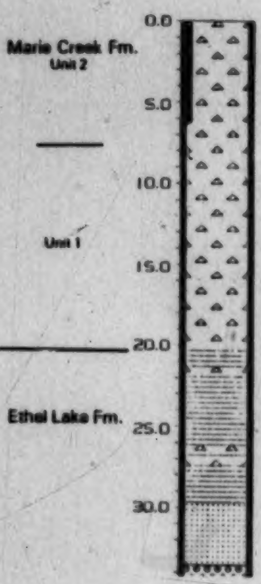
T51

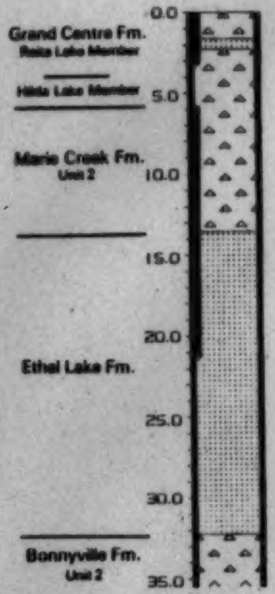
Alberta Geological Survey Testhole 1 51
Location: of LSD 1 Sec 17 Twp 59 Rng 7 W of 4 Mer , NTS 73L
Elevation: 2105 ft 642 M Source 1:50,000 NTS 73L/3
Date drilled: 197609 02 Logged by: M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METH	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00								11.8											
2.00								10.6				71.2	17.3	0.0	2.7	6.1	2.3	0.5	825
3.00	27.9	37.6	34.6	31.8	40.5	27.7	2.15	9.5				59.6	10.7	0.0	2.9	25.0	1.1	0.7	280
4.00	35.4	30.9	33.7	39.5	32.9	27.7	2.54	11.0				73.8	14.2	0.7	1.3	7.9	2.0	0.0	302
5.00	36.2	29.5	34.3	39.9	32.2	27.9	2.58	9.9				66.1	16.5	0.6	2.0	10.8	2.0	0.3	351
6.00	33.8	32.7	33.5	37.6	34.7	27.7	2.39	9.9				62.3	22.8	0.0	1.7	11.3	0.7	0.7	302
7.00	36.0	30.0	34.0	39.8	32.7	27.4	2.71	9.8				69.2	19.5	0.0	3.0	6.5	0.9	0.9	338
8.00	33.5	31.6	34.8	37.6	34.8	27.6	2.27	10.1				68.0	19.0	0.0	2.0	9.2	1.4	0.3	294
9.00	38.8	28.2	33.0	42.7	30.6	26.7	3.18	9.5				66.2	18.8	0.5	4.1	9.2	0.7	0.3	393
10.00	38.7	29.3	32.0	42.8	31.9	25.3	3.38	10.6				67.1	25.5	0.2	1.7	4.7	0.7	0.0	404
11.00	33.8	31.0	35.1	37.6	35.1	27.3	2.38	10.1				60.3	24.3	0.3	2.2	11.4	1.3	0.0	317
12.00	35.8	30.2	34.0	39.8	32.8	27.4	3.24	10.8				65.8	20.9	0.0	3.4	8.8	0.7	0.2	407
13.00	26.4	29.7	43.9	29.7	36.3	34.0	1.79	11.3				28.6	18.5	0.0	2.6	5.7	0.0	0.4	227
14.00	34.9	28.0	37.0	38.7	31.3	30.0	2.45	10.5				67.6	21.7	0.0	3.1	6.9	0.6	0.0	318
15.00	33.6	30.6	35.8	37.2	34.6	28.3	2.53	10.2				63.9	27.2	0.3	2.4	5.2	0.6	0.0	327
16.00	33.7	28.0	38.4	37.3	31.5	31.1	2.37	10.5				70.0	18.2	0.3	3.7	6.7	0.7	0.3	297
17.00	32.7	30.2	37.1	36.3	33.7	30.0	2.21	10.7				66.8	21.1	0.7	3.1	6.9	1.0	0.0	289
18.00	34.1	28.0	37.9	38.0	30.9	31.1	2.39	6.1				61.6	23.5	0.3	2.9	9.5	2.2	0.0	315
19.00	30.5	29.8	39.7	34.0	34.3	31.7	2.19	6.3				68.9	16.1	0.0	2.4	10.8	1.7	0.0	286
20.00	33.8	28.5	37.7	37.6	32.1	30.3	2.15	5.3				64.2	26.4	0.7	2.0	6.4	0.3	0.0	299
21.00								19.3											
22.00								15.1											
23.00								15.4											
24.00								16.7											
25.00	8.8	27.0	64.2	10.3	37.1	52.7	0.54	15.1				74.6	21.1	0.0	1.4	2.8	0.0	0.0	71
26.00	10.0	27.4	62.6	11.7	36.5	51.8	0.59	13.3				72.9	20.0	0.0	1.2	4.7	1.2	0.0	85
27.00								16.3											
28.00								16.2											

T52

Alberta Geological Survey Testhole: T 52
Location: of LSD 3 Sec 5 Twp 60 Rng 4 W of 4 Mer . NTS 73L
Elevation: 1970 Ft. 601 M Source 1:50,000 NTS 73L/2
Date drilled: 197608 03 Logged by: M. FENTON

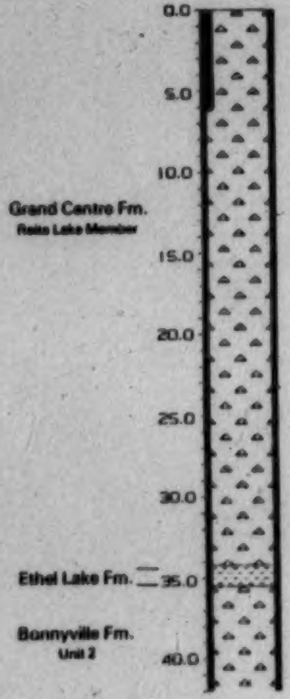


Grand Centre Fm.
Reita Lake Member
Hilda Lake Member
Marie Creek Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00	41.4	18.7	39.9	44.3	20.1	35.7	1.78	10.8				73.8	26.2	0.9	0.0	0.0	0.0	0.0	214
2.00																			
3.00	36.8	26.5	36.7	42.5	26.8	30.7	1.58	12.1				68.7	26.4	1.9	1.0	1.4	0.5	0.0	208
4.00	35.4	26.8	37.8	38.3	29.7	32.0	1.29	12.8				68.4	25.9	0.6	1.7	2.3	1.1	0.0	174
5.50	15.7	30.1	54.2	17.9	35.7	46.4	0.72					67.3	29.7	0.0	3.0	0.0	0.0	0.0	101
6.00	41.0	29.9	29.1	43.9	32.1	24.0	3.43	10.4				52.1	25.3	0.0	6.9	13.4	0.0	0.0	418
7.00	40.2	31.3	28.6	44.5	31.7	23.8	2.99	11.3											
8.00	39.8	30.2	29.9	42.6	32.5	24.9	3.34	11.4				56.6	23.0	0.5	4.8	12.6	2.4	0.0	413
9.00	40.1	33.1	26.8	44.1	33.6	22.2	3.10	11.1											
10.00	41.6	30.8	27.5	44.9	33.0	22.1	3.29	11.5				56.7	28.7	0.2	3.1	9.7	1.5	0.0	390
11.00	38.4	33.9	27.7	42.6	35.5	22.0	2.80	11.3											
12.00	39.6	31.9	28.4	43.6	32.8	23.5	2.81	11.1				58.0	35.5	0.0	5.8	8.2	2.5	0.0	364
13.00	39.3	31.5	29.2	43.7	32.5	23.8	2.76	11.0											
32.00	50.6	24.9	24.5	53.7	27.8	18.5	2.85					57.4	35.4	0.0	2.5	2.7	1.9	0.0	364
33.50	45.9	28.5	25.6	49.8	30.9	19.4	2.50					60.5	34.9	0.0	2.6	1.1	0.9	0.0	347

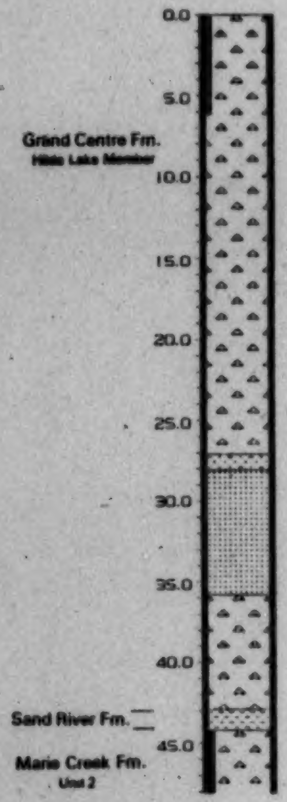
T53

Alberta Geological Survey Testhole T 53
Location of LSD 4 Sec 21 Twp 61 Rng 4 W of 4 Mer , NTS 73L
Elevation 1830 Ft 558 M Source 1:50,000 NTS 73L/7
Date drilled: 197609 04 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT OSS	LST	DST	LOC	OTH	N
1.00	36.5	26.2	37.3	41.0	28.1	30.9	1.49	12.8				67.6	27.4	0.5	0.5	2.9	1.0	0.0	204
2.00	37.8	27.7	34.5	42.4	29.7	27.8	1.53	13.0				66.0	26.4	0.5	2.0	4.6	0.5	0.0	197
3.00	38.0	26.3	35.7	42.7	27.9	29.4	1.64	15.1				65.8	25.7	1.0	2.0	4.4	1.0	0.0	202
4.00	38.3	28.6	33.1	43.2	29.6	27.3	1.80	13.2				62.3	30.7	0.9	2.2	3.1	0.9	0.0	228
5.00	38.3	27.9	33.8	43.2	29.2	27.7	1.87	13.8				70.8	23.3	0.0	0.4	2.7	2.8	0.0	219
6.00	38.6	30.7	30.7	43.5	32.3	24.2	1.67	10.7				54.2	35.5	0.0	4.0	8.9	1.3	0.0	225
7.00	37.2	26.4	36.4	41.8	26.5	31.7	1.31	11.1				59.5	33.3	0.5	2.2	3.8	0.5	0.0	183
8.00	36.1	32.6	31.3	41.4	34.7	23.9	1.52	10.9				72.2	23.9	0.0	1.9	1.9	0.0	0.0	205
9.00	39.8	26.5	33.7	44.1	29.3	26.6	2.35	10.4				71.5	24.3	0.6	0.6	2.4	0.3	0.3	334
10.00	41.9	29.8	28.3	46.3	33.7	19.9	2.57	9.7				75.1	22.0	0.6	1.3	0.6	0.0	0.3	313
11.00	39.6	29.0	31.3	44.7	30.3	25.0	1.87	9.6				71.8	23.5	0.4	2.1	1.3	0.8	0.0	238
12.00	39.8	30.3	29.9	44.5	32.9	22.6	2.13	9.9				72.5	22.5	0.4	2.3	2.3	0.0	0.0	262
13.00	37.1	27.8	35.1	41.3	31.1	27.6	1.36					64.7	31.0	0.5	0.0	2.2	1.0	0.5	184
14.00	36.0	30.2	33.8	40.9	31.2	27.9	1.54	10.5				67.5	29.0	1.0	1.5	0.5	0.5	0.0	200
15.00	39.5	27.6	32.9	44.1	30.8	25.1	1.73	10.0				66.7	26.1	0.5	1.9	3.9	0.5	0.0	207
16.00	35.7	30.5	33.8	40.7	34.9	24.4	1.42	10.0				73.9	20.3	1.1	0.5	2.1	1.0	0.0	187
17.00	31.7	32.3	36.0	35.6	36.4	28.0	1.40	11.0				67.4	30.5	0.5	0.0	1.6	0.0	0.0	187
18.00	43.1	26.6	30.4	47.6	27.6	24.8	1.76	9.4				75.2	21.7	0.0	0.9	1.7	0.0	0.4	230
19.00	36.5	29.6	33.9	41.6	31.4	27.1	1.50	10.4				71.0	24.5	0.5	2.5	1.5	0.0	0.0	200
20.00	33.5	29.2	37.3	37.6	32.3	30.1	1.21	11.5				77.1	19.8	0.6	1.2	0.6	0.6	0.0	166
21.00	36.5	29.7	33.7	41.3	33.0	25.8	1.67	10.5				68.9	26.5	1.4	0.4	2.7	0.0	0.0	219
22.00	36.5	29.6	33.9	41.1	31.8	27.0	1.61	10.9				68.7	28.0	1.4	1.4	0.9	0.0	0.0	214
23.00	36.3	30.9	32.8	41.1	31.7	27.2	1.32	10.9				75.5	21.7	0.0	1.1	1.1	0.5	0.0	180
24.00	35.2	28.7	36.1	39.7	29.9	30.4	1.46	11.0				67.3	28.4	0.5	1.0	1.0	1.0	0.5	193
25.00	31.0	36.0	32.9	36.1	38.2	25.6	1.25	11.2				71.8	19.2	0.0	0.6	6.4	1.3	0.6	156
26.00	36.7	28.5	34.8	41.3	30.3	28.4	1.39	11.0				74.6	23.7	0.6	1.1	0.0	0.0	0.0	173
27.00	34.7	28.4	36.9	39.5	31.1	29.4	1.60	11.4				72.4	24.0	0.0	1.0	2.5	0.0	0.0	196
28.00	36.3	27.4	36.2	40.8	29.3	29.9	1.49	10.5				75.5	18.9	0.5	2.2	2.8	0.0	0.0	180
29.00	34.7	28.0	37.3	39.0	31.6	29.6	1.45	11.6				73.6	19.9	1.5	1.0	4.0	0.0	0.0	201
30.00	34.9	30.6	34.4	39.9	31.9	28.2	1.55	11.3				77.0	20.6	0.0	0.5	1.5	0.5	0.0	204
31.00	35.1	30.7	34.1	40.3	32.5	27.2	1.65	11.1				68.8	26.6	0.0	1.4	2.3	0.0	0.9	218
32.00	35.5	30.2	34.3	40.5	31.2	28.3	1.83	11.2				69.9	27.8	0.4	0.4	1.3	0.0	0.0	223
33.50	29.3	37.0	33.7	34.0	38.8	27.2	1.11	12.7				76.0	20.7	2.0	0.0	1.3	0.0	0.0	190
34.00								17.7											
35.00	58.0	24.0	18.0	61.8	24.4	13.7	3.95	9.8				56.6	37.2	0.0	2.9	2.7	0.6	0.0	486
36.50	37.2	28.3	34.5	40.6	32.4	26.9	2.59	12.0				60.7	32.9	0.3	3.2	2.2	0.3	0.3	313
37.00	31.7	32.1	36.2	35.0	37.1	27.8	1.74	10.5				63.8	27.6	0.4	0.4	2.7	4.9	0.0	221
38.00	47.2	27.1	25.7	50.8	29.1	20.2	2.64	9.0				51.5	37.7	0.3	3.8	3.6	2.4	0.5	363
39.50	32.6	26.4	41.0	35.6	32.1	32.4	1.70	10.5				59.8	31.9	0.4	1.7	4.5	1.3	0.4	229
40.00	57.0	28.4	14.6	61.8	27.9	10.3	3.57					58.9	35.6	0.4	1.3	1.7	1.9	0.2	458

T54

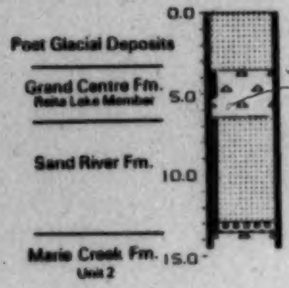


Alberta Geological Survey Testhole: T 54
Location of LSD 3 Sec 36 Twp 63 Rng 5 W of 4 Mer , NTS: 73L
Elevation: 1830 Ft 558 M Source 1:50,000 NTS 73L/7
Date drilled: 197608.05 Logged by: M FENTON

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZ/ USS	LST	DST	LOC	OTH	N
1.00								12.4											
2.00	33.0	25.2	41.8	35.9	28.4	35.7	1.29	13.4				60.8	33.3	1.2	1.2	2.3	1.2	0.0	171
3.00	40.8	27.2	32.0	45.0	27.8	27.1	1.46	12.7				56.1	34.0	1.4	4.2	3.8	0.0	0.5	212
4.00	29.0	23.3	47.7	31.5	27.6	40.8	1.20	14.2				69.5	23.8	0.0	1.8	2.4	1.8	0.6	164
5.00	27.8	27.2	45.1	31.3	30.2	38.5	1.17	14.8				69.6	21.4	0.7	3.4	4.1	0.7	0.0	145
6.00	30.2	32.9	36.9	33.9	34.5	31.6	0.78	13.8				67.2	25.0	1.7	2.6	0.0	3.4	0.0	116
7.00	28.9	35.4	35.7	33.7	36.7	29.6	0.86	23.6				65.5	31.1	1.7	1.7	0.0	0.0	0.0	119
8.00	29.9	33.3	36.8	33.8	36.1	30.1	0.76	13.6				75.4	20.0	0.0	3.6	0.9	0.0	0.0	110
9.00								13.8											
10.00	28.6	34.9	36.5	33.4	36.9	29.7	0.62	14.2				77.9	22.1	0.0	0.0	0.0	0.0	0.0	77
11.00								13.9											
12.00	30.5	33.4	36.1	34.2	36.5	29.3	0.82	13.8				63.6	30.3	4.0	1.0	0.0	1.0	0.0	99
13.00								14.0											
14.00	30.8	32.7	36.5	34.6	35.7	29.8	1.03	13.7				76.5	15.9	2.3	3.0	1.5	0.0	0.7	132
15.00								13.6											
16.00	28.9	35.1	36.1	33.6	38.1	28.3	0.80	13.5				71.4	22.8	1.9	3.8	0.0	0.0	0.0	105
17.00								13.3											
18.00	28.0	34.2	37.7	32.4	35.3	32.2	0.62	13.8				62.6	31.9	1.1	1.1	2.3	1.1	0.0	91
19.00								13.8											
20.00	30.9	29.9	39.2	34.1	34.2	31.7	1.07	13.7				76.2	21.6	0.8	0.8	0.8	0.0	0.8	125
21.00								14.1											
22.00	30.5	27.4	42.1	34.4	31.1	34.5	0.98	14.0				67.6	28.3	2.1	0.7	0.7	0.7	0.0	145
23.00								14.3											
24.00	29.8	26.4	43.8	33.0	32.4	34.5	0.94	13.9				59.2	35.2	1.6	0.8	3.2	0.0	0.0	125
25.00	29.1	29.0	41.9	33.1	34.5	32.4	0.95	13.9				75.0	18.1	0.9	4.3	0.9	0.0	0.9	116
26.00	31.1	27.7	41.2	34.1	32.4	33.5	1.12	13.6				71.5	23.8	2.0	2.0	0.7	0.0	0.0	151
27.00								12.4											
36.50	28.5	27.4	44.1	32.4	31.9	35.7	0.77	12.4				72.1	24.3	0.9	0.0	1.8	0.9	0.0	111
37.00	28.3	27.4	44.3	31.3	30.9	37.8	0.92	12.9				78.5	17.7	2.8	0.0	0.9	0.0	0.0	107
38.00	28.9	28.8	42.3	32.9	31.1	36.0	0.96	12.9				68.2	27.3	0.7	1.5	0.7	0.0	1.5	132
39.50	29.3	28.4	42.2	32.4	31.6	36.0	0.73	12.9				71.0	23.0	1.0	2.0	3.0	0.0	0.0	100
40.00	28.5	27.9	43.6	32.3	30.7	37.0	0.96	12.7				73.3	22.4	0.0	2.6	1.7	0.0	0.0	116
41.00	31.9	27.1	41.0	34.8	30.0	35.2	0.82	12.8				73.7	22.8	1.7	0.0	1.7	0.0	0.0	114
42.50								14.9											
43.00								14.9											
44.00	42.0	25.7	32.2	45.4	28.2	26.3	3.76	10.3				59.7	22.3	0.0	2.5	14.0	1.4	0.0	479
45.00	39.1	29.4	31.4	42.5	31.1	26.4	2.60	10.2				54.8	23.5	0.0	3.7	16.7	0.9	0.3	323
46.00	36.0	30.5	33.5	40.3	31.8	27.9	2.17	11.5				57.0	19.9	0.0	3.4	18.2	1.3	0.0	291
47.00	35.3	30.0	34.7	38.6	32.8	28.6	2.31	11.5				53.2	22.5	0.0	5.4	17.2	1.6	0.0	297

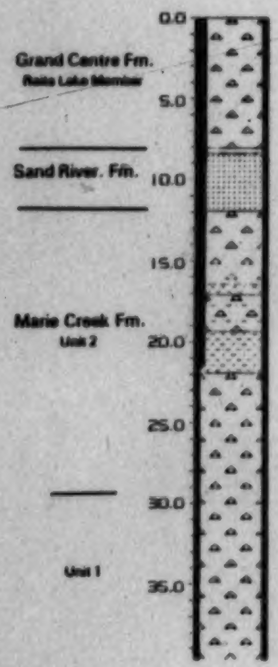
T55

Alberta Geological Survey Testhole . 1 55
Location: NE of LSD 1 Sec 26 Twp 63 Rng 4 W of 4 Mer . NTS 73L
Elevation 1800 Ft. 549 M Source 1:50,000 NTS 73L/8
Date drilled 197609.05 Logged by: M. FENTON


0.0
Post Glacial Deposits
Grand Centre Fm.
Reita Lake Member
5.0
Sand River Fm.
10.0
Marie Creek Fm.
Unit 2
15.0

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZI USS	LST	DST	LOC	OTH	N
4.00								17.8											
5.00								16.9											
6.00								15.0											
14.00								10.6											

T56

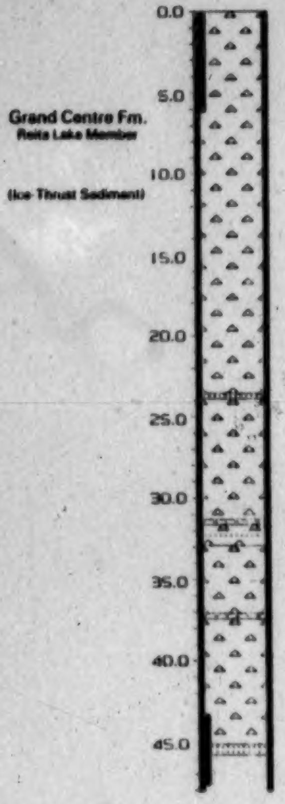


Alberta Geological Survey Testhole T 56
Location: of LSD 14 Sec 6 Twp 63 Rng 4 W of 4 Mer , NTS 73L
Elevation 1800 Ft. 549 M Source 1:50,000 NTS 73L/7
Date drilled 197609 06 Logged by M FENTON

	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	ICN METM	QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1.00	36.8	24.6	38.6	41.1	26.1	32.7	1.51	11.0				67.3	28.1	1.4	0.9	1.4	0.0	0.5	211
2.00	37.8	26.2	36.0	41.1	28.4	30.5	1.33	11.1				67.0	25.8	1.0	3.1	2.1	1.0	0.0	194
3.00	39.4	25.3	35.3	43.1	27.8	29.1	1.77	10.6				70.9	24.5	0.0	1.7	2.1	0.8	0.0	237
4.00	37.3	29.2	33.5	41.0	30.5	28.5	1.56	10.7				69.4	26.2	1.0	0.5	1.9	0.5	0.5	206
5.00	37.2	25.3	37.5	40.9	28.2	30.8	1.59	10.9				75.4	21.2	0.5	0.0	1.4	0.5	1.0	207
6.00	38.1	25.9	36.1	43.6	25.8	30.6	1.62	9.8				68.7	25.1	0.5	2.4	1.9	1.4	0.0	211
7.00	36.1	32.3	31.6	41.8	32.6	25.6	1.10	9.0				68.2	26.0	0.0	1.9	1.9	0.6	1.3	154
8.00	34.1	29.6	36.4	38.0	31.5	30.4	1.05	9.8				74.8	16.3	1.4	0.7	3.4	1.4	2.0	147
9.00																			
10.00																			
11.00																			
12.00	38.8	30.8	30.5	43.4	32.2	24.4	2.91	8.3				59.6	21.1	0.3	2.8	14.2	1.2	0.6	317
13.00	37.2	32.2	30.6	41.3	33.0	25.6	2.55	8.7				57.3	23.0	0.0	4.5	13.9	1.2	0.0	308
14.00	37.5	32.7	29.8	42.5	33.3	24.2	2.49	8.0				60.4	18.0	0.0	3.0	17.1	1.5	0.0	333
15.00	39.8	34.7	25.5	44.6	34.6	20.9	2.47					58.6	23.4	0.3	3.1	11.4	2.7	0.3	324
16.00	30.9	45.3	23.8	36.9	44.3	18.8	1.80					59.6	20.7	0.0	3.4	15.3	1.0	0.0	203
17.00	13.9	65.8	20.3	21.7	61.8	16.5	0.80	11.8				57.7	18.3	0.0	4.8	22.1	2.0	0.0	104
18.00	35.4	42.4	22.2	39.3	42.9	17.8	2.64	12.1				60.6	17.9	0.3	3.0	16.1	1.5	0.6	335
19.00								16.5											
20.00								15.3											
21.00								9.1											
22.00	40.0	36.5	23.5	44.4	36.5	19.1	2.95	10.3				58.3	23.1	0.0	4.3	12.2	1.5	0.2	393
23.00	44.1	31.4	24.5	48.8	32.6	18.7	3.40	9.8				58.7	21.7	0.0	3.8	14.8	0.7	0.3	424
24.00	50.0	28.2	21.8	53.7	29.0	17.3	3.51	8.6				58.9	24.8	0.0	2.9	10.8	1.3	0.2	452
25.00								8.9											
26.00	46.2	29.4	24.3	51.1	30.2	18.6	3.21	8.7				61.1	24.0	0.0	3.2	10.1	1.0	0.2	463
27.00								9.0											
28.00	44.5	29.6	25.9	48.3	31.1	20.6	2.61	9.4				60.1	23.7	0.3	3.5	11.8	0.6	0.0	346
29.00								9.1											
30.00	23.9	23.8	52.3	26.5	31.6	42.0	1.27	12.8				52.0	34.5	0.6	7.9	2.8	2.2	0.0	177
31.00								12.7											
32.00	24.3	24.7	51.0	26.6	31.7	41.7	1.26	12.6				61.4	29.0	0.0	1.7	5.1	2.9	0.0	176
33.50								9.4											
34.00	36.3	26.6	37.2	40.2	30.0	29.8	2.74	10.6				65.1	26.1	0.0	2.7	5.2	0.9	0.0	364
35.00								9.7											
36.50	37.8	25.8	36.4	40.8	29.6	29.6	3.11	9.4				64.4	26.7	0.2	1.8	4.3	2.6	0.0	393
37.00	36.0	26.4	37.7	39.8	29.9	30.3	2.56	9.9				65.7	25.3	0.3	4.1	4.8	0.3	0.0	344
38.00	36.8	25.3	37.9	39.8	30.0	30.3	3.23					64.9	26.1	0.2	2.9	3.9	1.8	0.0	410
39.50																			

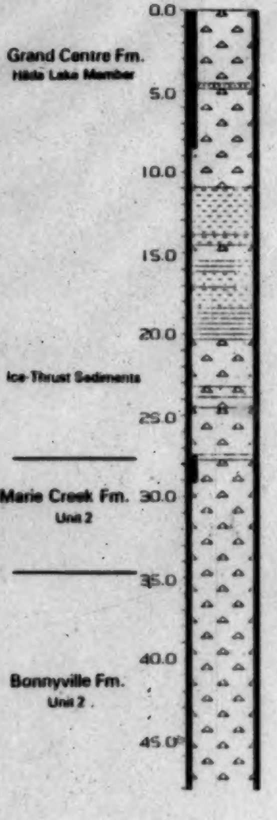
T57

Alberta Geological Survey Testhole T 57
Location of LSD 16 Sec 8 Twp 60 Rng 5 W of 4 Mer., NTS 73L
Elevation 2050 ft 625 M Source 1:50,000 NTS 73L/2
Date drilled 197610 19 Logged by M. FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	36.5	22.6	40.9	39.3	24.6	36.1	1.25	11.0											
2.00	34.0	26.0	40.0	37.9	28.4	33.7	1.58	10.7				63.9	27.8	1.0	2.4	4.4	0.5	0.0	205
3.00	37.1	25.1	37.7	39.9	28.1	32.1	1.52	12.2				69.4	23.7	0.9	0.7	3.9	0.8	0.4	435
4.00	37.7	26.7	35.6	41.9	28.1	30.0	1.36	12.6				74.0	20.7	0.8	1.4	2.5	0.5	0.0	631
5.00	39.3	25.1	35.6	42.5	27.2	30.4	1.79	11.7											
6.00	39.4	24.1	36.6	42.5	26.4	31.1	1.91	11.7				73.7	25.9	0.9	1.8	1.3	0.9	0.0	224
7.00	37.2	25.4	37.5	41.6	26.9	31.4	1.67	12.8											
8.00	36.3	25.8	37.8	39.6	28.6	31.8	1.72	11.1											
9.00	36.1	26.9	37.0	40.2	28.5	31.2	2.58	12.0				75.7	20.5	1.0	1.2	0.5	0.9	0.0	404
10.00	38.1	25.2	36.7	41.2	27.7	31.1	1.84	12.1				68.1	29.1	0.9	0.5	0.9	0.5	0.0	213
11.00	36.3	27.1	36.6	40.6	28.4	30.9	1.35	12.0											
12.00	37.5	25.0	37.5	40.4	27.6	31.9	1.23	12.2				66.2	28.6	1.9	1.2	1.9	0.0	0.0	154
13.00	36.4	25.5	38.1	40.6	27.0	32.4	1.29	11.7											
14.00	37.3	24.2	38.5	40.5	26.2	33.3	1.60	11.9											
15.00	38.7	26.6	34.7	42.7	28.0	29.3	1.74	11.0				69.7	24.3	0.4	1.6	1.6	0.8	1.6	505
16.00	41.0	24.0	35.0	44.0	26.5	29.5	1.85	11.4				72.2	20.8	0.7	1.2	2.1	1.3	1.4	418
17.00	40.8	24.4	34.8	44.0	27.3	28.6	1.81	11.4											
18.00	39.6	24.7	35.7	43.7	26.9	29.4	1.94	11.8				72.0	24.6	1.4	1.1	1.1	0.0	0.0	264
19.00	40.9	24.1	35.0	43.9	27.3	28.0	2.01	11.5				72.7	24.6	0.4	1.5	0.8	0.0	0.0	260
20.00	40.9	26.1	33.0	45.3	27.0	27.7	2.11	11.3											
21.00	28.7	28.9	42.3	31.5	34.2	34.2	1.58	12.8				77.9	18.9	0.8	1.0	0.8	0.5	0.0	38
22.00	34.2	28.9	36.9	38.4	32.2	29.4	1.86	12.1				74.8	20.7	1.3	1.3	1.3	0.4	0.0	448
23.00	28.0	28.8	43.3	30.9	34.3	34.8	1.31	12.1											
24.00	28.5	28.9	42.6	32.3	33.1	34.6	1.43	12.0											
25.00	27.9	28.1	44.0	30.6	33.1	36.2	1.45	12.4											
26.00	26.7	29.8	43.4	30.2	33.9	35.8	1.50	12.3				72.4	23.4	1.6	1.0	1.0	0.5	0.0	192
27.00	22.9	28.3	48.8	25.4	34.0	40.5	1.37	12.9				76.8	19.5	0.0	1.7	0.5	1.1	0.3	358
28.00	24.1	29.9	46.1	27.6	34.2	38.2	1.29	12.2				78.9	18.9	0.7	0.4	0.7	0.4	0.0	535
29.00	24.9	28.5	46.6	29.0	32.6	38.1	1.75	12.6											
30.00	25.5	46.1	28.5	28.9	58.3	12.8	1.45	13.0											
31.00								14.8											
32.00	38.1	28.4	33.5	41.1	32.3	26.5	1.53	11.9				72.3	23.2	1.1	2.8	0.0	0.6	0.0	177
33.50	41.1	28.0	30.9	45.4	29.6	25.0	1.77	11.0				70.7	27.1	0.4	0.4	1.3	0.0	0.0	229
34.00	44.7	26.3	29.0	48.3	27.8	23.9	1.65	10.8				70.8	27.3	0.0	0.9	0.5	0.5	0.0	216
35.00	44.9	27.3	27.7	49.8	27.6	22.6	1.82	10.3											
36.50	38.8	25.6	35.6	41.8	28.8	29.4	1.27	10.8				71.8	25.4	1.1	0.5	1.1	0.0	0.0	181
37.00	30.2	26.5	43.2	33.8	30.9	35.3	1.12	12.0				77.0	16.5	2.1	2.1	1.4	0.7	0.0	139
38.00	32.0	25.6	42.3	34.7	30.5	34.9	0.98	12.0											
39.50	28.5	26.8	44.7	31.7	31.4	36.9	1.54	11.5				71.6	22.4	1.9	2.5	1.5	0.0	0.0	201
40.00	26.0	23.6	50.4	28.0	30.7	41.3	0.84	13.7				71.3	24.3	2.6	0.9	0.9	0.0	0.0	116
41.00	28.6	22.1	49.3	31.3	27.5	41.2	1.50	13.4				74.9	23.0	0.5	0.0	1.0	0.5	0.0	191
42.50	14.2	20.8	65.0	15.4	29.7	54.9	0.43	13.6											
43.00	36.5	30.5	32.9	40.6	33.2	27.2	2.45	10.4											
44.00								10.6											
45.00								8.6				62.1	21.0	0.7	4.4	11.5	0.6	0.0	314
46.00								8.4											
47.00								11.5											

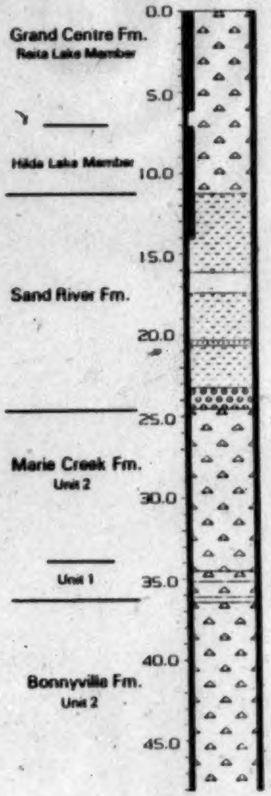
T58



Alberta Geological Survey Testhole T 58
Location of LSD 16 Sec 13 Twp 63 Rng 2 W of 4 Mer . NTS 73L
Elevation 1850 Ft 564 M Source 1:50,000 NTS 73L/8
Date drilled 197610 20 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZ/ USS	LST	DST	LOC	OTH	N
1.00	46.7	30.0	23.2	50.7	30.2	19.1	3.05	9.2				60.2	30.9	0.2	4.2	2.1	2.0	0.0	475
2.00	47.2	29.0	23.8	51.2	29.5	19.4	3.23	9.2	29.1	12.2	0.26	66.4	24.8	0.7	3.7	2.5	1.7	0.0	408
3.00	48.4	27.4	24.1	52.3	27.8	19.8	3.48	8.7	32.0	13.4	0.36	64.4	26.1	0.4	3.1	3.4	2.6	0.0	716
4.00	47.5	27.1	25.4	51.3	27.2	21.4	3.04	9.6	31.8	13.4	0.34	61.4	29.9	0.5	3.5	3.3	1.3	0.0	599
5.00	53.4	25.3	21.4	57.1	25.2	17.7	3.46	8.7	24.1	10.2	0.42	56.8	35.1	1.3	4.3	1.5	0.9	0.0	461
6.00	50.3	25.4	24.3	53.8	26.0	20.2	3.55	8.9	33.0	13.8	0.32	63.0	29.1	0.4	3.4	1.9	2.1	0.0	467
7.00	52.5	25.4	22.1	56.1	26.0	17.9	4.29	8.9	33.5	14.1	0.41	64.4	28.2	0.7	3.7	1.6	1.4	0.0	564
8.00	59.5	20.1	20.3	62.3	21.6	16.1	7.41	9.1	35.2	14.8	0.36	64.0	30.8	0.4	2.4	1.1	0.2	0.0	458
9.00	27.4	36.7	35.9	30.5	43.1	26.3	1.96	12.4	30.2	12.7	0.34	55.3	23.9	0.8	9.6	3.7	6.7	0.0	490
10.00	27.3	35.0	37.6	30.5	41.0	28.4	1.98	12.2	29.8	12.5	0.37	53.8	26.7	0.0	10.8	4.8	4.1	0.0	539
11.00	25.7	36.5	37.8	28.9	42.0	29.0	1.39	12.4				54.9	25.8	0.3	6.3	3.8	8.3	0.0	364
12.00								16.1											
13.00								17.0											
14.00	29.2	35.8	35.0	32.3	39.7	28.1	1.62	13.5				47.9	36.6	0.4	3.5	5.5	6.2	0.0	549
15.00	33.1	28.4	38.6	36.4	31.6	32.0	2.22	12.3				43.5	37.0	0.7	4.9	5.4	8.7	0.0	448
16.00								14.3											
17.00								15.9											
18.00	1.4	38.8	59.9	3.2	48.9	47.9	0.12	15.4											
19.00								15.0											
20.00								15.6											
21.00	23.7	30.2	46.1	26.7	35.9	37.4	1.01	12.9	25.2	10.6	0.35	70.4	22.9	1.1	1.8	3.5	0.4	0.0	284
22.00	20.8	32.1	47.1	23.6	37.5	38.8	0.84	12.6	24.9	10.5	0.32	64.6	21.4	1.6	4.3	5.4	2.8	0.0	257
23.00	23.7	31.4	45.0	26.9	35.3	37.8	0.98	12.0	25.1	10.5	0.26	58.2	26.3	1.8	4.6	6.0	3.2	0.0	285
24.00	17.8	34.0	48.2	21.2	38.7	40.1	0.76	23.9	18.7	7.8	0.34	59.3	29.4	1.0	5.0	2.7	2.8	0.0	221
25.00	23.7	30.7	45.7	26.9	34.8	38.3	0.90	14.8	18.7	7.9	0.33	72.3	20.5	0.8	1.2	2.4	2.8	0.0	249
26.00	23.2	32.6	44.2	26.6	37.0	36.4	0.90	13.2	25.9	10.9	0.31	66.7	20.8	4.6	5.6	1.9	0.0	0.0	216
27.00								13.1	23.5	9.9	0.38								
27.50	46.1	26.3	27.6	50.1	27.5	22.4	3.33		27.7	11.6	0.29	64.8	26.8	0.8	3.9	2.0	1.7	0.0	611
29.00	46.0	26.3	27.8	49.7	29.3	21.0	2.98	7.8	38.3	16.0	0.19	62.8	22.6	1.9	2.7	9.3	0.5	0.0	376
30.00	45.0	29.5	25.4	48.8	33.3	17.9	3.02	8.4	33.0	13.8	0.31	60.9	25.7	1.0	5.3	4.7	2.3	0.0	471
31.00	45.1	29.4	25.4	48.8	32.5	18.7	2.88		31.6	13.3	0.36	64.9	22.6	1.1	6.5	4.0	1.1	0.0	402
32.00	45.6	28.7	25.8	49.3	32.3	18.4	3.56	8.4	32.2	13.6	0.39	64.7	22.8	1.3	4.8	3.2	2.9	0.0	377
33.50	43.6	28.7	27.7	47.2	31.4	21.4	3.60	8.6	32.7	13.8	0.41	62.6	25.9	0.2	4.6	1.9	4.1	0.0	522
34.00	44.1	30.7	25.2	47.7	31.5	20.7	3.28		32.2	13.6	0.35	63.4	26.7	1.1	3.1	3.5	2.2	0.0	606
35.00	48.6	34.9	16.5	52.3	31.1	16.6	3.21	7.2	30.6	12.9	0.36	63.2	26.8	0.0	4.2	2.7	2.8	0.0	451
36.50	51.9	26.3	21.7	55.4	28.9	15.7	3.16	7.0				57.9	32.0	0.3	5.0	3.0	1.6	0.0	397
37.00	51.8	29.0	19.3	55.1	30.1	14.9	3.05	7.1	32.5	13.6	0.34	55.8	32.9	0.0	4.1	4.1	2.8	0.0	414
38.00	60.8	21.3	17.9	63.7	21.9	14.4	3.45					56.0	34.3	0.8	3.2	3.2	1.6	0.0	373
39.50	54.5	21.8	23.7	57.5	22.9	19.6	2.97	8.4	30.1	12.7	0.37	59.0	31.3	0.3	4.2	2.4	2.6	0.0	668
40.00	50.9	23.9	25.2	54.0	25.0	21.0	2.82	6.7				61.7	28.9	0.3	5.8	1.4	1.9	0.0	360
41.00	50.1	27.3	22.5	53.7	29.7	16.7	3.45	7.7	30.0	12.7	0.44	62.4	27.2	0.0	4.4	2.9	3.1	0.0	412
42.50	51.0	25.4	23.6	54.2	27.9	17.9	2.81	7.7				60.9	27.7	0.0	5.0	3.2	2.7	0.0	340
43.00	53.0	25.2	21.9	56.4	26.9	16.7	4.01	9.4	34.2	14.4	0.36	60.0	29.8	0.9	3.2	3.6	2.5	0.0	560
44.00	51.2	26.4	22.4	54.5	28.8	16.7	3.02	7.6				57.1	32.0	0.9	3.7	3.2	3.2	0.0	438
45.00	49.2	26.9	23.8	52.7	29.8	17.4	3.15	7.6	32.6	13.7	0.38	55.6	34.4	1.0	4.1	3.3	1.6	0.0	390
46.00	50.4	25.7	23.9	53.7	27.7	18.5	2.85	10.0				60.4	24.9	0.5	6.0	4.9	3.0	0.0	449
47.00	52.6	24.7	22.7	56.1	26.5	17.4	2.49	8.9	33.8	14.3	0.43	61.3	29.1	0.6	4.1	3.3	1.8	0.0	669

T59

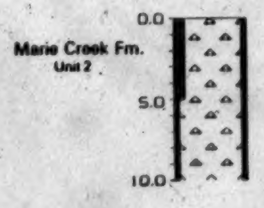


Alberta Geological Survey Testhole T 59
Location of LSD 1 Sec 21 Twp 63 Rng 3 W of 4 Mer , NTS 73L
Elevation 1790 Ft 546 M Source 1 50,000 NTS 73L/8
Date drilled 197610 21 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	I OK	OTH	N
1.00	31.0	22.0	47.0	33.0	26.0	41.0	1.61	11.9	13.1	5.5	0.40	76.3	19.6	2.3	0.5	0.9	0.5	0.0	219
2.00	36.0	24.0	39.0	40.0	26.0	34.0	1.96	10.7	32.2	13.5	0.32	70.8	23.0	2.3	0.4	3.1	0.4	0.0	257
3.00	22.0	29.0	49.0	24.0	33.0	43.0	1.33	14.1				63.9	25.6	0.6	5.0	4.4	0.6	0.0	180
4.00	19.0	22.0	59.0	22.0	38.0	40.0	1.47	16.7	18.7	7.9	0.49	64.1	26.5	1.2	1.2	5.3	1.8	0.0	170
5.00	38.0	23.0	39.0	42.0	25.0	33.0	2.10	12.7				73.8	22.2	0.0	0.4	1.8	0.7	0.0	275
6.00	32.0	29.0	39.0	36.0	31.0	33.0	1.37	11.1	28.3	11.9	0.19	67.0	23.6	2.2	2.2	5.0	0.0	0.0	182
7.00	28.0	39.0	33.0	34.0	37.0	29.0	0.88	11.9				69.8	16.0	0.0	4.7	8.5	0.9	0.0	106
8.00	29.0	38.0	33.0	34.0	39.0	27.0	0.96	10.1	28.2	11.8	0.18	61.5	20.5	0.0	4.3	12.8	0.9	0.0	117
9.00	28.0	40.0	32.0	34.0	39.0	28.0	0.88	11.2				66.0	25.5	0.9	0.9	5.7	0.9	0.0	106
10.00	29.0	38.0	34.0	33.0	38.0	29.0	0.94	10.6	27.7	11.6	0.28	61.3	20.2	0.8	2.5	10.9	4.2	0.0	119
11.00	28.0	39.0	34.0	33.0	38.0	29.0	0.98	10.7				61.8	20.9	1.8	0.9	14.6	0.9	0.0	110
12.00	41.0	38.0	22.0	46.0	36.0	18.0	2.17	10.4	29.5	12.4	0.24	79.2	16.4	1.1	0.4	1.1	0.7	0.0	274
13.00	35.0	44.0	22.0	39.0	43.0	18.0	1.18	9.8				77.6	13.9	3.0	1.8	3.0	0.6	0.0	165
14.00	29.0	44.0	27.0	33.0	45.0	21.0	0.97	11.6				77.0	14.8	3.0	0.7	1.5	3.0	0.0	135
15.00								8.6											
18.00								11.5											
19.00								9.1											
20.00								9.7											
21.00	26.0	49.0	25.0	30.0	51.0	19.0	0.92	9.8				75.0	23.1	6.7	1.0	3.9	0.0	0.0	104
22.00	28.0	50.0	21.0	34.0	49.0	18.0	0.90	12.9				73.4	21.8	2.4	0.8	1.6	0.0	0.0	124
23.00								10.4											
24.50	47.0	28.0	24.0	51.0	31.0	19.0	3.83		43.0	15.8	0.13	58.8	22.7	0.9	3.7	12.6	1.3	0.0	454
25.00	44.0	32.0	24.0	49.0	34.0	18.0	3.23	8.2				59.7	22.0	0.5	4.3	12.9	0.7	0.0	419
26.00	40.0	33.0	26.0	44.0	36.0	20.0	2.89	8.5	42.2	17.6	0.15	62.5	20.1	1.2	3.5	12.5	0.3	0.0	344
27.00	46.0	33.0	21.0	51.0	34.0	15.0	3.55	7.8				63.5	17.0	0.7	3.0	14.0	1.3	0.0	430
28.00	45.0	27.0	28.0	49.0	30.0	21.0	2.69	8.1	39.0	16.3	0.17	63.9	23.8	0.0	5.0	5.9	0.9	0.0	357
29.00	45.0	28.0	27.0	49.0	31.0	20.0	2.95	8.4				64.7	22.5	1.1	2.8	9.3	2.3	0.0	355
30.00	47.0	26.0	27.0	50.0	29.0	20.0	2.64	8.6	34.2	14.4	0.33	57.1	29.8	0.6	1.7	8.5	2.3	0.0	352
31.00	23.0	21.0	56.0	25.0	34.0	42.0	2.20	12.2				54.0	30.9	0.4	4.5	7.6	2.6	0.0	265
33.00	50.0	26.0	24.0	54.0	29.0	18.0	3.08	7.7	31.4	13.2	0.27	58.5	30.0	1.0	3.2	5.9	1.5	0.0	410
34.00	37.0	23.0	40.0	39.0	30.0	31.0	2.48	7.6	33.6	14.0	0.15	52.3	33.3	0.0	3.7	8.1	1.9	0.0	321
35.00	40.0	26.0	34.0	44.0	31.0	26.0	2.62					57.9	29.1	0.9	4.3	3.8	4.1	0.0	347
36.00	29.0	24.0	47.0	32.0	31.0	37.0	1.53	11.8				59.3	24.3	0.0	5.8	6.6	4.0	0.0	226
37.00	46.0	30.0	24.0	50.0	33.0	17.0	2.91	10.1	27.7	11.6	0.32	59.5	29.5	0.5	5.8	4.0	0.3	0.0	397
38.00	48.0	27.0	26.0	51.0	28.0	20.0	3.50		24.0	10.1	0.39	61.0	28.3	0.0	4.9	4.5	1.1	0.0	449
39.50	47.0	28.0	25.0	51.0	30.0	19.0	3.43					57.3	30.3	0.7	5.0	4.1	2.6	0.0	459
41.00	48.0	29.0	24.0	52.0	31.0	18.0	3.52	8.8	32.8	13.8	0.30	57.4	30.4	0.6	1.8	4.4	2.1	0.0	477
42.50	48.0	28.0	24.0	52.0	30.0	18.0	3.33	8.5				60.0	26.3	1.1	5.5	3.7	3.3	0.0	457
43.00	49.0	27.0	24.0	53.0	29.0	19.0	3.47		34.2	14.3	0.27	60.9	26.2	0.9	5.0	4.6	2.2	0.0	458
44.00	51.0	26.0	23.0	55.0	28.0	17.0	3.77					58.8	32.4	1.0	3.7	1.7	2.3	0.0	481
48.00	58.0	22.0	19.0	62.0	23.0	15.0	3.31		21.3	9.1	0.59	52.8	37.3	0.7	5.3	1.9	1.7	0.0	413

T61

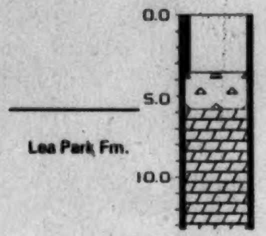
Alberta Geological Survey Testhole: T 61
Location: SW of LSD 4 Sec 29 Twp 58 Rng 6 W of 4 Mer. NTS: 73L
Elevation: 2160 Ft 659 M Source: 1:50,000 NTS 73L/2
Date drilled 197610 20 Logged by: M. FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								10.5											
2.00	31.0	38.3	30.6	34.9	38.6	26.5	2.15	9.4				55.5	15.5	0.0	7.3	21.2	0.4	0.0	245
3.00	37.5	31.9	30.6	41.3	32.7	26.1	2.72	9.2				58.6	23.4	0.6	4.7	12.4	0.3	0.0	338
4.00	36.8	32.2	31.0	40.7	32.7	26.6	2.81	9.3				56.5	24.4	0.0	3.8	13.6	1.6	0.0	368
5.00	36.7	32.4	31.0	40.2	33.6	26.2	2.86	9.1				61.2	21.9	0.0	4.8	11.2	1.1	0.0	374
6.00	36.6	32.0	31.3	40.5	33.5	26.0	2.72	8.6				57.1	24.3	0.3	4.2	11.8	2.1	0.0	329
7.00	37.2	32.6	30.2	40.7	34.0	25.4	3.01	9.2				58.5	25.6	1.0	3.6	10.1	1.0	0.2	386
8.00	37.5	31.2	31.3	41.3	36.1	22.6	2.85	8.5				57.3	24.9	0.5	3.8	12.7	0.8	0.0	370
9.00	38.6	29.6	31.8	42.4	30.8	26.8	2.71	8.6				54.6	28.6	0.9	4.0	11.1	0.6	0.0	350
10.00	39.7	29.4	30.9	43.2	31.2	25.6	2.96	9.5											

T62

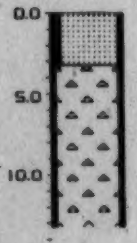
Alberta Geological Survey Testhole: T 62
Location: SE of LSD 4 Sec 6 Twp 60 Rng 6 W of 4 Mer , NTS 73L
Elevation: 1825 Ft 556 M Source: 1:50,000 NTS 73L/2
Date drilled 197610 20 Logged by M. FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								18.9											
3.00								14.4											
4.00								12.1											
5.00								12.0											
6.00								15.5											
7.00								16.0											
8.00								17.2											
9.00								16.5											
10.00								16.4											
11.00								15.4											
12.00								15.5											

T63

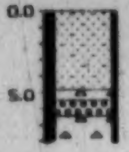
Alberta Geological Survey Testhole: T 63
Location: of LSD 16 Sec 15 Twp 63 Rng 7 W of 4 Mer , NTS: 73L
Elevation: 1850 Ft. 564 M Source: 1:50,000 NTS 73L/7
Date drilled: 197610 21 Logged by M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00								9.3											
3.00								15.0											
4.00								3.4											
5.00								7.8											
6.00								4.7											
8.00								13.2											
11.00								4.1											
12.00								4.1											
13.00								7.3											

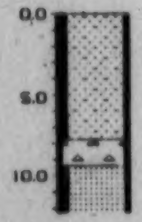
T64

```
Alberta Geological Survey Testhole    1  64
Location     of LSD  7 Sec 15 Twp  63 Rng  7 W of 4 Mer ;  NTS  73L
Elevation   1850 Ft     564 M   Source  1:50,000 NTS 73L/7
Date drilled    197610.21  Logged by  M  FENTON

                 TEXTURE (%)                          MATRIX CARBONATE         COARSE SAND LITHOLOGY (%)
DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H2O    CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
 (M) >62 5um     <4um  >50um      <2um 1-2mm  (%)   (cc)  (%)         METM         QSS

 2.50
 4.00
 5.00
 6.00
 7.00
 8.00
```



T65

Alberta Geological Survey Testhole T 65
Location: of LSD 4 Sec 3 Twp 63 Rng 7 W of 4 Mer . NTS 73L
Elevation: 1850 Ft 564 M Source: 1 50,000 NTS 73L/7
Date drilled: 197610 21 Logged by: M FENTON.



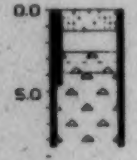
	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
7.00								15.6											
9.00								9.7											

T66

```
Alberta Geological Survey Testhole    1  66
Location:    of LSD  5 Sec 22 Twp  62 Rng  6 W of 4 Mer ,  NTS  73L
Elevation:  1830 Ft.    558 M   Source  1:50,000 NTS 73L/7
Date drilled:   197610.21  Logged by  M. FENTON

                    TEXTURE (%)                          MATRIX CARBONATE         COARSE SAND LITHOLOGY (%)
DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H2O    CO2  CO3 CA/DO     IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
 (M) >62.5um     <4um  >50um     <2um 1-2mm   (%)   (cc)  (%)          METM        QSS
   1.00
   2.50
```

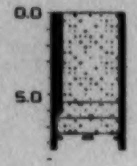
T67

```
Alberta Geological Survey Testhole   T  67
Location      of LSD  4 Sec  7 Twp  64 Rng  5 W of 4 Mer ,  NTS  73L
Elevation:  1850 Ft.     564 M   Source  1:50,000 NTS 73L/10
Date drilled     197610 21  Logged by  M  FENTON

                    TEXTURE (%)                         MATRIX CARBONATE          COARSE SAND LITHOLOGY (%)
DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD  H2O    CO2  CO3 CA/DO     IGN   QTZ  QTZT  LST  DST  LOC  OTH   N
 (M) >62 5um     <4um  >50um     <2um 1-2mm  (%)   (cc)  (%)           METM        QSS
```



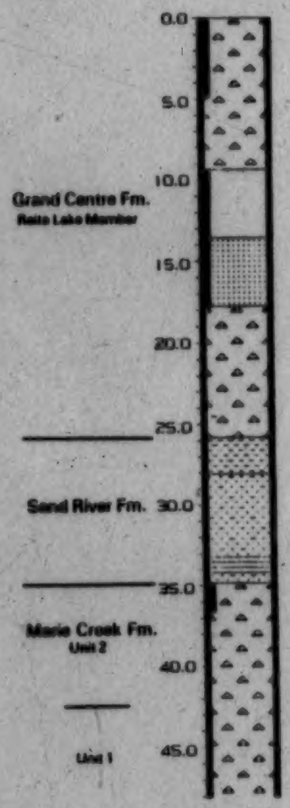
T68

```
Alberta Geological Survey Testhole:   1  68
Location:  NE of LSD  4 Sec 35 Twp  63 Rng  5 W of 4 Mer  ,  NTS  73L
Elevation:  1850 Ft    564 M   Source: 1:50,000 NTS 73L/7
Date drilled:    197610.21  Logged by: M. FENTON

                    TEXTURE (%)                          MATRIX CARBONATE          COARSE SAND LITHOLOGY (%)
 DEPTH  SAND SILT CLAY  SAND SILT CLAY VC SD   H20    CO2  CO3 CA/DO    IGN   QTZ  QTZT  LST  DST  LOC  OTH    N
  (M) >62 5um     <4um  >50um     <2um 1-2mm   (%)   (cc)  (%)          METM       QSS
```



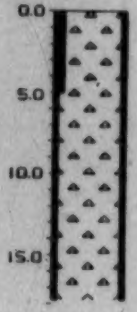
T69

Alberta Geological Survey Testhole 1 69
Location of LSD 12 Sec 29 Twp 63 Rng 6 W of 4 Mer , NTS 73L
Elevation 1875 Ft 572 M Source 1:50,000 NTS 73L/7
Date Drilled: 197610.23 Logged By M. FENTON



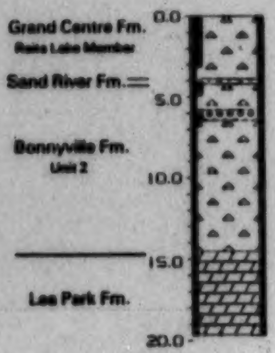
	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								10.8											
2.00	37.3	25.4	37.3	40.8	27.2	32.0	2.26	11.0				64.0	27.1	1.2	1.6	4.8	1.2	0.0	247
3.00	35.4	30.8	33.8	39.6	32.3	28.2	1.70	10.1				68.6	25.6	2.2	0.9	1.3	0.9	0.0	223
4.00	36.5	29.0	34.5	40.4	30.5	29.1	1.71	10.1				65.9	26.5	0.9	2.2	3.1	1.3	0.0	226
5.00	39.0	26.9	34.1	43.3	27.5	29.3	1.74	10.2				77.1	19.1	1.7	2.6	0.4	0.0	0.0	230
6.00	39.6	26.9	33.5	43.6	27.6	28.8	1.93	10.8				76.6	19.3	0.0	1.4	1.1	1.4	0.0	274
7.00	37.9	26.7	35.4	41.9	28.2	29.9	2.11	11.7				67.8	27.0	0.0	2.1	2.8	0.3	0.0	289
8.00	42.5	25.3	32.2	46.5	26.4	27.1	2.49	10.6				70.4	23.6	0.9	1.6	3.5	0.0	0.0	314
9.00	39.1	26.7	34.2	43.2	27.8	29.0	1.53	10.5				68.5	26.0	0.0	2.5	2.5	1.0	0.0	200
18.00	35.8	28.0	36.2	39.7	32.2	28.1	1.44	9.7				69.5	24.0	1.5	2.0	2.5	0.0	0.0	200
19.00	34.4	30.4	35.2	38.3	33.6	28.2	1.50	9.8				69.9	26.5	0.5	0.5	2.5	0.0	0.0	196
20.00	35.9	27.0	37.1	40.1	30.0	29.9	1.66	9.3				70.8	25.0	1.3	0.8	1.7	0.0	0.4	236
21.00	35.8	27.3	36.9	39.5	31.8	28.7	1.44	9.5				69.6	25.1	1.6	1.0	1.6	1.0	0.0	191
22.00	36.0	26.8	37.2	40.0	31.4	28.6	1.58	9.7				73.6	23.1	0.5	0.5	2.3	0.0	0.0	212
23.00	37.0	26.2	36.8	40.7	31.4	27.8	1.39	10.1				74.1	22.3	0.0	2.0	1.0	0.5	0.0	197
24.00	27.3	38.4	34.3	32.9	40.9	26.2	0.72	9.6				66.0	27.0	0.0	5.0	2.0	0.0	1.0	101
25.00	25.1	41.4	33.6	30.3	43.6	26.1	0.47	10.2				70.5	22.9	0.0	1.6	4.9	0.0	0.0	61
26.00								14.0											
28.00								19.9											
29.00								20.1											
30.00								18.0											
31.00								15.8											
34.00								16.2											
35.00	33.5	32.5	34.0	37.5	36.0	26.5	2.00	12.7				55.8	23.1	0.3	3.8	15.8	1.0	0.0	285
36.50	38.1	33.2	28.6	42.0	36.4	21.6	2.55	9.3				61.2	19.9	1.9	2.9	13.3	0.3	0.3	307
37.00	38.5	33.2	28.3	42.7	36.9	20.4	2.77	8.7				60.7	19.4	0.5	3.0	15.5	0.5	0.3	361
38.00	40.9	31.7	27.4	44.8	35.2	20.0	3.11	9.6				59.3	21.5	0.2	4.8	13.4	0.7	0.0	396
39.50	38.7	38.5	22.8	43.0	39.4	17.7	2.66	8.1				52.0	27.2	1.1	3.6	14.9	1.1	0.0	356
40.00	48.2	32.9	18.9	53.0	31.9	15.1	3.21	8.3				57.7	23.7	0.8	3.3	13.6	0.8	0.0	388
41.00	60.5	26.4	13.1	64.9	24.0	11.1	4.81	8.4				59.6	26.4	0.3	2.9	9.8	0.6	0.3	307
42.50	36.9	29.0	34.1	40.3	31.2	28.5	2.68	8.5				59.4	28.8	0.3	3.3	7.5	0.6	0.0	333
43.00	30.9	27.7	41.4	34.1	31.8	34.2	2.11	9.6				59.9	29.6	0.3	2.4	5.6	1.7	0.0	287
44.00	32.0	29.0	39.0	35.1	33.1	31.9	2.20	9.2				62.4	29.4	0.3	0.7	5.1	2.0	0.0	293
45.00	30.2	27.3	42.5	33.4	31.8	34.8	2.00	10.1				64.4	25.5	0.4	2.6	6.4	0.7	0.0	267
46.00	32.5	24.2	43.2	35.4	29.2	35.4	2.64	9.7				65.0	25.8	0.6	2.1	5.2	1.2	0.0	329
47.00	31.7	28.7	39.6	36.1	32.6	32.3	2.22	8.7				61.8	28.5	1.3	1.0	5.8	1.3	0.3	309

Alberta Geological Survey Testhole T 70
Location: of LSD 9 Sec 4 Twp 61 Rng 5 W of 4 Mer , NTS 73L
Elevation: 1850 Ft 564 M Source: 1 50,000 NTS 73L/2
Date drilled 197610.22 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								11.4											
2.00								5.8											
3.00								6.1											
4.00								12.6											
5.00								11.9											
6.00								14.1											
10.00								5.5											
11.00								11.9											
12.00								6.9											
14.00								6.5											
15.00								11.3											
16.00								11.9											
17.00								12.1											

T71

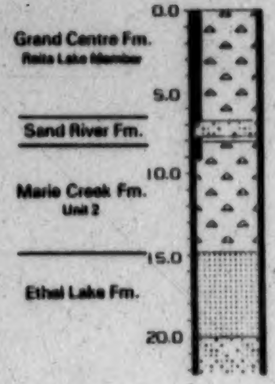


Alberta Geological Survey Testhole T 71
Location: of LSD 9 Sec 25 Twp 59 Rng 6 W of 4 Mer , NTS 73L
Elevation 1825 Ft 556 M Source: 1 50,000 NTS 73L/2
Date drilled: 197610 22 logged by: M FENTON

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00	35.1	25.3	39.5	39.0	25.7	35.3	1.50	17.5				62.7	26.5	1.0	4.1	3.1	1.0	1.5	196
2.00	37.4	27.1	35.5	40.4	28.1	31.6	1.64	14.2				70.0	26.0	0.5	2.5	1.0	0.0	0.0	200
3.00	28.6	24.1	47.3	31.3	26.7	42.0	1.30	15.6				73.7	20.5	0.6	3.8	0.6	0.6	0.0	156
4.00								20.3											
5.00	42.4	28.9	28.6	46.7	28.1	25.1	2.46	12.5				60.1	34.6	0.3	2.9	0.3	1.8	0.0	341
7.00	45.0	28.1	26.8	48.2	30.3	21.6	2.46					62.0	30.0	0.3	4.7	2.0	0.9	0.0	340
8.00	42.3	28.9	28.9	46.7	30.0	23.3	2.62	8.9				52.8	33.3	0.3	6.3	4.8	2.1	0.3	333
9.00	42.9	26.8	30.3	46.0	30.0	24.0	2.32	10.7				57.7	31.7	0.0	4.3	4.3	1.5	0.0	322
10.00	40.9	28.0	31.1	45.1	30.2	24.7	2.81	11.4				59.5	31.6	0.0	3.9	1.8	2.9	0.0	383
11.00	41.3	26.7	32.0	44.5	30.4	25.1	2.28	10.5				58.0	32.0	0.3	4.3	2.0	3.3	0.0	300
12.00	39.7	27.5	32.8	44.0	29.5	26.5	2.69	10.8				55.5	37.1	0.0	2.7	2.7	1.8	0.0	369
13.00	40.7	26.1	33.2	43.8	29.9	26.3	2.59	11.2				55.8	33.7	0.3	5.1	3.6	1.2	0.0	335
14.00	39.8	26.8	33.4	43.8	29.5	26.7	3.54	12.9				56.3	32.3	0.2	5.4	3.6	2.2	0.0	446
15.00								17.4											
16.00								16.9											
18.00								17.1											
19.00								19.4											

T72

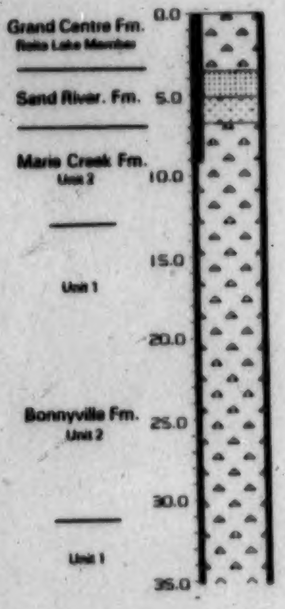
Alberta Geological Survey Testhole: T 72
Location: SE of LSD 8 Sec 1 Twp 60 Rng 1 W of 4 Mer , NTS 73L
Elevation: 1900 Ft 579 M Source 1:50,000 NTS 73L/1
Date drilled: 197610 23 Logged by: ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	45.8	22.3	31.8	49.5	22.5	28.0	2.51	11.6				73.0	24.9	1.0	0.1	0.8	1.0	0.0	762
2.00	43.1	24.8	32.1	46.9	26.1	27.1	2.23	11.1				69.5	25.9	2.0	0.6	1.4	0.9	0.0	351
3.00	43.8	25.2	30.9	47.6	26.1	26.3	2.35	11.4				71.1	24.2	1.2	0.7	1.7	1.2	0.0	422
4.00	44.0	24.2	31.8	47.8	25.4	26.7	2.38	11.6				73.7	23.9	1.1	0.5	0.5	0.8	0.0	377
5.00	42.4	25.2	32.3	46.2	26.6	27.2	2.03	11.1				68.4	35.5	2.4	1.3	1.9	0.6	0.0	376
6.00	37.7	24.3	38.0	41.3	26.2	32.5	1.89	11.8				70.7	26.4	1.1	0.7	1.4	0.4	0.0	280
8.00	24.7	25.3	49.9	27.9	30.0	42.1	0.79	17.3				82.2	16.0	0.6	0.0	0.6	0.0	0.0	163
9.00	38.2	29.5	31.4	42.6	32.0	25.4	3.37	9.6				62.2	21.0	0.9	4.0	10.7	1.4	0.0	580
10.00	39.7	28.9	30.3	43.3	33.1	23.7	3.52	9.9				61.6	24.7	1.1	1.7	9.5	1.5	0.0	539
11.00	37.8	31.3	30.9	41.1	35.2	23.7	3.12	9.8				60.2	23.0	0.6	4.3	10.6	1.7	0.0	530
12.00	38.6	31.2	30.2	41.9	34.5	23.6	2.86	9.5				68.6	19.3	0.0	3.7	8.7	0.5	0.0	404
13.00	32.5	29.0	38.5	35.3	34.9	29.9	2.52	10.6				66.7	22.9	0.8	1.4	5.5	2.5	0.0	363
14.00	43.2	24.7	32.1	46.0	28.5	25.4	3.02	9.5				57.6	32.7	-0.3	4.3	3.1	1.8	0.0	953

T73

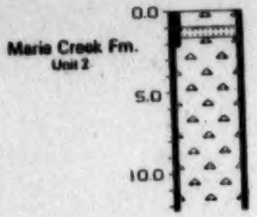
Alberta Geological Survey Testhole T 73
Location of LSD 9 Sec 6 Twp 65 Rng 7 W of 4 Mer . NTS 73L
Elevation 2020 Ft 616 M Source 1 50,000 NTS 73L/11
Date drilled 197610.24 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN + MET M	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00								9.7				59.9	26.5	0.6	7.4	4.3	1.2	0.0	162
2.00	38.4	25.5	36.1	47.1	26.4	31.5	1.27	8.8				72.9	24.1	1.3	0.0	0.0	1.6	0.0	236
3.00	46.4	24.1	29.5	50.4	23.4	26.2	1.76	9.7											
6.00								14.5				64.2	22.0	0.6	3.5	8.9	0.9	0.0	346
7.00	40.9	36.7	22.4	46.1	35.7	18.2	2.64	11.9				61.5	23.2	0.3	4.5	9.6	0.9	0.0	353
8.00	40.3	37.7	22.1	45.2	37.6	17.2	2.95	11.3				57.7	26.6	0.3	3.7	10.0	1.8	0.0	350
9.00	41.0	35.7	23.3	45.7	36.9	17.4	2.66	10.2				63.2	21.7	0.0	2.9	11.2	0.6	0.0	313
10.00	40.7	38.0	21.3	45.4	39.3	15.2	2.50	9.6				64.7	24.2	0.3	1.9	8.0	0.8	0.0	360
11.00	42.5	35.0	22.5	47.0	36.6	16.4	2.93	9.9				59.7	28.8	0.0	3.5	7.3	0.6	0.0	385
12.00	44.2	36.1	19.7	48.6	36.4	14.9	2.97	9.5				63.1	31.4	0.0	1.6	2.3	1.6	0.0	256
13.00	33.5	28.9	37.6	37.3	32.6	30.2	2.10	11.4				53.3	36.7	0.0	3.3	4.6	2.1	0.0	240
14.00	29.8	32.8	37.4	33.5	37.5	29.0	1.89	12.0				60.0	33.3	0.0	3.0	1.5	2.2	0.0	135
15.00	20.9	36.2	42.9	23.8	42.5	33.7	1.06	12.4				60.4	29.9	0.0	5.8	1.9	1.3	0.6	154
16.00	21.2	37.7	41.1	24.3	43.3	32.4	1.17	12.4				59.7	28.0	0.0	3.0	7.3	2.4	0.0	165
17.00	23.5	32.1	44.4	26.6	37.7	35.7	1.28	12.6				65.9	30.6	0.0	2.3	1.2	0.0	0.0	85
18.00	11.3	34.0	54.7	12.5	47.2	40.2	0.64	15.7				57.4	33.0	0.0	5.6	2.5	1.0	0.0	197
19.00	24.1	34.3	41.6	26.5	41.4	32.1	1.58	12.4				59.8	33.1	0.0	2.8	3.2	0.4	0.4	251
20.00	28.5	34.9	36.5	31.7	40.5	27.8	2.02	12.9				66.2	26.8	0.3	2.6	3.6	0.0	0.3	302
21.00	38.5	28.5	33.0	42.4	32.4	25.2	2.29	10.8				67.8	25.1	1.8	4.2	0.3	0.7	0.0	283
22.00	36.6	30.0	33.4	40.4	34.8	24.9	1.94	10.9				60.6	31.7	0.8	2.7	2.3	2.0	0.0	259
23.00	36.7	28.9	34.4	40.5	33.9	25.7	1.95	10.7				59.7	30.7	0.3	5.7	1.8	1.5	0.3	335
24.00	41.4	29.3	29.4	45.3	33.5	21.2	2.45	3.7				54.7	37.0	0.0	3.3	3.3	1.2	0.0	305
25.00	41.8	27.7	30.5	45.8	31.9	22.3	2.31	4.1				65.1	27.8	0.0	3.4	2.4	1.3	0.0	295
26.00	41.7	26.9	31.4	46.0	32.1	22.0	2.13	4.6				62.6	30.4	0.0	1.4	2.8	2.7	0.0	289
27.00	39.8	25.9	34.3	43.9	30.0	26.0	2.19	4.9				64.7	28.1	0.6	3.0	2.2	1.4	0.0	366
28.00	38.3	29.1	32.6	41.9	34.4	23.7	2.71	9.8				65.8	28.1	0.6	2.6	1.3	1.6	0.0	310
29.00	38.4	25.9	35.7	42.0	31.4	26.6	2.46	9.5				68.7	27.4	0.3	0.8	2.2	0.5	0.0	368
30.00	37.7	27.4	34.9	41.3	33.2	25.5	2.87	10.0				68.1	24.5	0.0	3.7	2.0	1.6	0.0	298
31.00	32.8	24.2	43.0	36.5	30.9	32.6	2.28	10.6				62.3	31.5	0.4	2.9	1.8	0.8	0.0	273
32.00	32.0	26.6	41.4	35.2	34.3	30.5	2.03	10.8				64.7	28.8	0.0	2.7	2.7	1.2	0.0	337
33.50	35.2	23.9	41.0	38.4	30.5	31.0	2.61	10.1				60.3	32.7	0.0	2.7	3.4	0.6	0.0	290
34.00	37.0	26.7	36.3	40.5	33.3	26.2	2.15	8.8				66.7	27.5	0.4	2.5	0.7	1.4	0.7	276
35.00	36.1	24.1	39.8	39.6	30.0	30.4	2.12	11.7											

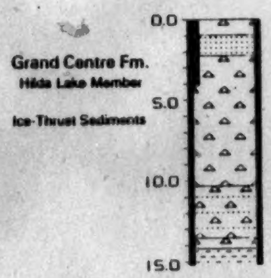
T74

Alberta Geological Survey Testhole: 1 74
Location: N of LSD 11 Sec 1 Twp 63 Rng 3 W of 4 Mer . NTS 73L
Elevation: 1775 Ft 541 M Source: 1 50,000 NTS 73L/8
Date drilled: 197610 24 Logged by: ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN MFTM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	60.7	21.2	18.1	61.8	22.6	15.6	4.11					65.3	23.2	0.5	2.6	5.4	2.5	0.0	613
3.00	44.2	26.0	29.8	45.2	31.7	23.2	2.49	9.0				60.0	29.1	0.6	3.7	4.5	1.6	0.2	515
4.00	45.0	24.3	30.7	45.9	29.3	24.7	2.49					63.5	25.3	1.3	2.4	4.3	3.0	0.0	375
5.00	42.7	26.6	30.7	43.6	32.2	24.2	2.32					60.8	26.9	1.6	3.2	6.5	1.6	0.0	372
6.00	42.4	25.6	32.0	43.4	31.2	25.4	2.47	9.3				62.6	25.8	1.3	2.4	5.3	2.1	0.4	713
7.00	43.4	25.0	31.6	44.3	30.3	25.3	2.43	9.3				60.8	28.8	0.9	2.0	5.5	2.0	0.0	451
8.00	42.9	25.4	31.7	43.9	30.4	25.7	2.46	9.3				67.3	22.8	1.0	1.7	4.7	2.3	0.0	404
9.00	42.9	25.3	31.8	43.9	30.4	25.7	2.82	9.2				65.6	23.1	0.6	3.4	4.6	2.7	0.0	477
10.00	44.2	24.6	31.2	45.2	29.6	25.2	2.72					69.4	22.8	1.1	2.2	3.5	0.8	0.0	461
11.00	44.7	26.5	28.8	45.7	30.9	23.4	2.80	9.0				65.9	24.7	0.8	2.4	3.6	2.4	0.0	502
12.00	42.9	23.9	33.2	43.8	29.8	26.4	2.84	9.7				63.0	28.0	0.2	3.3	4.1	1.0	0.2	511

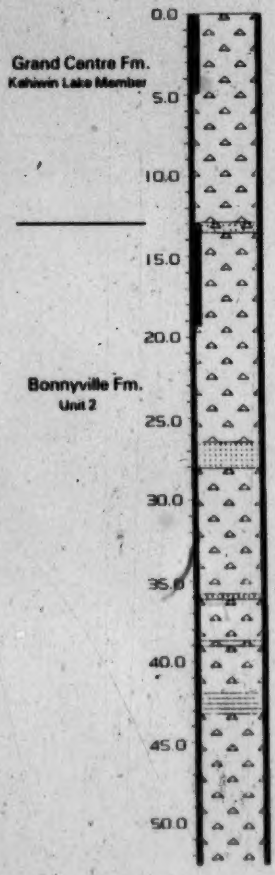
T75



Alberta Geological Survey Testhole T 75
Location: SW of LSD 6 Sec 26 Twp 62 Rng 2-W of 4 Mer . NTS 73I
Elevation: 1875 Ft. 572 M Source 1:50,000 NTS 73L/8
Date drilled: 197610 24 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00	46.7	27.5	25.9	50.4	27.3	22.3	3.61	11.2				57.5	26.4	0.0	3.8	10.1	2.2	0.0	318
2.00	57.3	25.2	17.6	60.8	23.9	15.3	4.22					62.4	21.2	0.3	4.0	9.4	2.7	0.0	372
3.00	47.5	26.9	25.6	51.1	26.4	22.5	3.20	10.4				65.8	24.8	0.0	3.0	3.4	3.0	0.0	298
4.00	42.3	29.8	27.9	45.9	30.0	24.1	2.98	10.8				62.9	27.3	0.4	3.1	4.3	2.0	0.0	256
5.00	45.6	28.8	25.5	49.3	29.7	21.0	3.03	10.1				60.5	28.1	0.0	5.9	2.4	3.2	0.0	253
6.00	47.8	29.4	22.8	51.6	30.5	17.9	3.30	10.1				59.5	29.9	0.3	4.1	3.4	2.4	0.3	291
7.00	37.1	35.7	27.2	40.1	40.2	19.7	2.17	11.2				54.9	36.8	0.0	3.9	1.5	3.0	0.0	337
8.00	54.6	24.0	21.4	58.0	24.8	17.3	3.54	11.1				58.4	34.4	0.0	2.6	1.9	2.6	0.0	308
9.00	27.5	38.1	34.5	30.7	41.7	27.6	1.84	13.2				56.5	26.7	0.0	7.3	5.0	4.6	0.0	262
10.00	31.1	36.9	32.0	34.6	38.8	26.6	2.39	12.5				58.7	28.1	0.6	7.2	8.7	5.4	0.0	334
11.00								13.1											
12.00	40.1	29.7	30.1	42.8	33.1	24.1	2.04	11.9				55.4	20.4	0.0	6.5	6.0	11.7	0.0	397
13.00	62.4	19.8	17.9	65.1	20.0	14.9	6.75					66.5	18.7	0.0	7.2	4.3	3.2	0.0	278
14.00	51.5	26.5	22.0	54.9	27.0	18.2	4.22	11.2				56.1	22.1	0.0	10.1	5.3	6.2	0.0	417
14.60								18.0											

77 SR 1

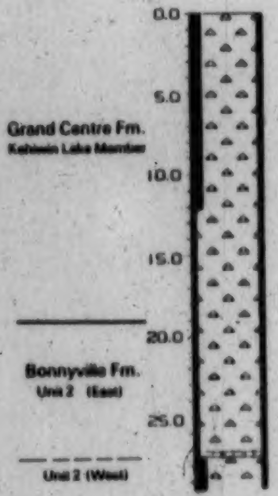


Alberta Geological Survey Testhole 77 SR 1
Location: of LSD 1 Sec 28 Twp 58 Rng 8 W of 4 Mer , NTS 73L
Elevation 2100 Ft 640 M Source 1:50,000 NTS 73L/3
Date drilled: 197707 20 Logged by M FENTON

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN MI/TM	QTZ	QTZI USS	LSI	DSI	LOC	OTH	N
1.00								11.6				65.9	22.9	1.7	0.9	6.1	2.3	0.0	341
2.00	38.0	43.2	18.8	40.7	44.8	14.5	1.36	12.2				66.9	23.8	1.0	3.6	3.3	1.3	0.0	390
3.00	40.1	40.8	19.0	43.1	40.6	16.3	1.52	10.7				65.9	26.0	0.8	4.0	2.4	0.8	0.0	496
4.00	38.9	42.4	18.7	41.8	43.9	14.4	1.82	10.8				67.8	23.8	0.6	4.0	2.9	0.8	0.0	478
5.00								10.7				62.1	29.9	0.6	3.0	2.8	1.3	0.2	531
6.00	41.3	40.6	18.1	44.3	42.2	13.5	2.47	10.6				65.3	26.8	0.2	4.6	2.0	0.8	0.2	459
7.00								11.1											
8.00	44.1	39.2	16.8	47.0	39.5	13.5	2.67	10.7											
9.00								10.5											
10.00	44.4	39.6	16.0	47.3	40.1	12.5	2.63	10.8				66.5	26.4	0.4	0.8	4.8	1.2	0.0	504
11.00								11.1				68.2	24.9	0.7	2.9	2.4	0.7	0.0	545
12.00	37.0	43.8	19.2	40.3	44.8	14.9	2.14	11.3											
13.00	29.0	47.8	23.1	31.5	48.3	20.3	1.35	12.3											
14.00	31.2	48.5	20.4	33.7	52.1	14.1	1.48	14.2				61.6	34.0	0.3	1.9	1.9	0.3	0.0	315
15.00								13.9											
16.00	28.7	49.4	21.9	31.6	51.0	17.4	1.21	14.3				54.7	36.2	0.6	3.7	1.9	2.8	0.0	320
17.00								14.3				57.3	37.3	0.3	2.3	1.0	1.3	0.0	300
18.00	33.4	46.7	19.9	36.0	48.0	16.0	1.66	13.7				54.1	38.8	0.8	1.8	0.8	3.7	0.0	508
19.00								13.9				58.6	32.7	1.2	2.5	1.2	2.5	0.0	324
20.00	31.6	47.9	20.5	34.5	50.5	15.0	1.35	13.7				46.8	46.0	0.0	3.2	2.1	1.6	0.3	374
21.00								13.2				58.9	33.6	0.6	2.9	2.5	1.3	0.2	518
22.00	34.4	47.0	18.6	37.0	50.6	12.3	1.75	12.8				57.4	36.1	0.5	3.6	1.5	0.8	0.0	390
23.00								12.8				62.6	30.5	0.3	2.3	3.9	0.3	0.0	305
24.00	36.0	46.3	17.7	38.9	49.6	11.5	1.96	12.8				60.9	34.5	0.6	1.5	1.2	0.9	0.3	333
25.00								11.9											
26.00	40.0	44.2	15.8	42.8	47.1	10.1	2.20	11.9											
27.00																			
28.00	38.5	44.0	17.4	41.5	47.2	11.3	1.69	12.3											
29.00	41.9	42.5	15.6	44.5	45.7	9.8	2.29	13.6				59.9	34.5	0.9	2.7	0.4	1.3	0.2	446
30.00								11.6											
31.00	41.8	41.2	16.9	44.7	44.5	10.7	2.00	11.2											
32.00								11.7											
33.50	42.2	40.9	16.9	44.8	44.5	10.7	1.69	10.7											
34.00								10.5											
35.00								10.1				63.9	27.2	0.7	4.7	2.2	1.0	0.2	405
36.00	48.9	38.0	13.1	51.7	39.0	9.3	3.73	10.7				59.7	32.5	0.4	1.5	3.7	0.9	1.3	539
37.00								9.8				64.0	29.3	0.8	2.4	1.3	1.6	0.5	375
38.00	44.2	39.6	16.2	47.0	41.9	11.1	1.86	10.8				59.8	29.9	0.7	3.9	2.0	3.6	0.0	438
39.50								10.5				62.3	32.5	0.6	2.1	1.2	1.2	0.0	329
40.00	41.5	41.6	16.8	45.0	43.0	12.0	1.58	11.8				59.3	30.7	0.2	4.6	2.3	2.6	0.2	388
41.00	27.3	51.9	20.7	31.6	53.2	15.2	0.72	12.5				62.5	30.1	0.7	4.0	1.8	0.7	0.0	272
42.50								25.4											
43.00								13.7				60.0	26.5	0.4	5.3	5.1	2.2	0.6	532
44.00	25.9	50.9	23.1	29.3	52.3	18.4	1.31	13.6											
46.00								14.0				57.8	29.7	0.0	3.0	6.4	2.7	0.3	296
47.00	26.2	50.5	23.4	29.6	53.0	17.5	1.15	13.6				60.2	27.9	0.0	4.4	5.0	1.9	0.6	480
48.00								13.6				57.2	25.8	0.4	6.7	4.5	5.2	0.2	554
49.00	32.0	45.1	23.0	34.8	47.6	17.6	1.38	13.0				56.9	29.2	0.7	3.3	6.2	3.7	0.0	568
50.00	33.9	44.2	21.9	36.7	47.0	16.3	2.14	12.5				64.3	27.1	0.9	3.5	3.2	0.9	0.0	339
51.00	35.9	43.4	20.7	39.0	45.6	15.4	1.58	11.1											
52.00	35.3	43.5	21.2	38.1	46.8	15.1	1.56	11.7				53.6	36.0	0.6	3.4	4.1	2.2	0.0	319
53.00	32.2	47.9	19.9	35.4	50.8	13.8	1.41	12.2				61.9	26.1	0.9	5.3	1.8	2.5	1.2	323

77 SR 2

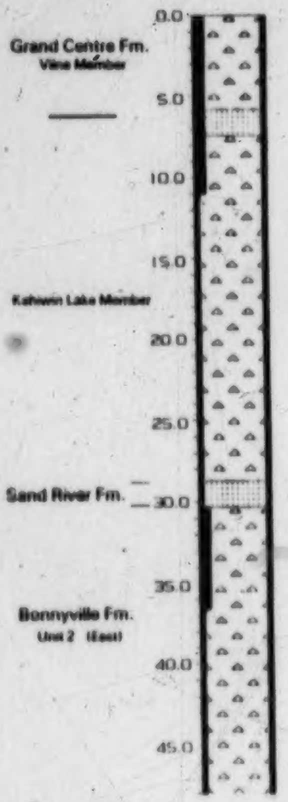
Alberta Geological Survey Testhole: 77 SR 2
Location of LSD 4 Sec 17 Twp 58 Rng 7 W of 4 Mer , NTS 73L
Elevation 2175 Ft 636 M Source 1 50,000 NTS 73L/3
Date drilled 197707 21 Logged by C LUTZAK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND -62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN WEIH	QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1.00								10.7	11.7	4.9	0.31	65.4	29.4	1.4	2.7	0.8	1.9	0.0	367
2.00	37.1	31.0	31.9	39.9	34.4	25.7	1.81	11.8	18.2	7.6	0.38	66.2	23.9	0.3	4.9	2.8	1.8	0.0	284
3.00	32.5	32.6	35.0	35.1	36.6	28.3	0.76	12.3	9.4	3.9	0.12	60.3	30.0	2.1	2.8	3.6	1.1	0.0	280
4.00	39.5	28.5	32.0	42.0	32.0	26.0	2.13	11.4	16.5	6.9	0.26	59.0	32.1	0.5	2.7	3.5	2.1	0.0	371
5.00	38.6	29.9	31.6	41.1	32.8	26.0	1.87	11.3	15.9	6.7	0.46	61.2	31.1	0.3	2.1	3.1	2.1	0.0	382
6.00	38.7	29.9	31.3	41.3	28.6	30.2	1.86	11.5	15.4	6.5	0.30	63.2	31.0	0.7	2.4	1.7	0.9	0.0	419
7.00	43.8	31.3	24.8	46.5	29.7	23.7	1.69	10.1	10.2	4.3	0.24	59.1	35.1	2.0	2.0	0.6	1.1	0.0	350
8.00								10.7	15.5	6.5	0.22	61.1	34.5	0.9	0.0	1.1	2.6	0.0	345
9.00	37.9	30.5	31.6	40.7	29.2	30.1	1.47	10.8	14.7	6.2	0.55	61.4	31.5	0.8	1.6	1.6	3.2	0.0	378
10.00								10.9	14.9	6.3	0.43	59.6	29.4	1.3	2.4	2.4	5.1	0.0	374
11.00	35.7	33.1	31.2	38.4	31.9	29.7	1.69	10.6	13.7	5.8	0.44	59.9	31.5	1.4	3.3	1.1	2.8	0.0	362
12.00								10.8	13.7	5.7	0.33	56.7	31.9	0.8	3.1	2.6	4.5	0.3	351
13.00	35.9	37.6	26.5	38.6	36.2	25.3	1.56	11.2	15.4	6.5	0.35	60.5	31.6	1.6	3.4	0.8	2.4	0.0	377
14.00	35.5	40.1	24.3	38.2	39.6	22.3	1.63	11.4	16.5	7.0	0.39	58.4	32.2	0.8	2.9	1.9	1.6	2.4	373
15.00								10.5	14.7	6.2	0.33	54.6	34.6	2.3	4.0	2.0	2.3	0.3	350
16.00	35.7	42.6	21.7	38.4	41.2	20.3	1.52	10.8	13.6	5.7	0.34	54.2	36.0	0.8	4.7	2.2	1.4	0.5	358
17.00								11.1	15.4	6.5	0.41	55.1	33.5	2.1	4.0	2.1	3.1	0.0	421
18.00	37.8	42.3	19.9	40.5	40.9	18.6	1.40	9.8	13.4	5.6	0.38	56.5	38.4	0.8	1.3	1.6	1.1	0.3	375
19.00								10.0	13.7	5.8	0.39	65.0	27.5	3.4	0.9	2.2	0.9	0.0	323
20.00	42.8	38.8	18.3	45.7	37.3	17.0	1.70	9.5	13.7	5.8	0.41	56.8	37.9	1.5	0.6	2.1	0.9	0.6	338
21.00								9.7	12.8	5.4	0.31	53.8	39.1	1.5	1.5	1.8	1.8	0.3	327
22.00	43.8	41.3	14.9	46.7	39.9	13.4	1.47	9.3	10.6	4.5	0.32	48.0	43.4	1.8	2.1	1.8	2.5	0.3	325
23.00	42.8	38.4	18.7	45.8	37.0	17.3	1.69	9.4	13.0	5.4	0.29	54.9	40.7	0.9	1.1	0.9	1.4	0.0	346
24.00	41.4	40.6	18.0	44.2	39.5	16.3	1.91	9.5	13.7	5.8	0.32	61.2	34.0	1.4	1.4	1.1	0.8	0.0	353
25.00	44.8	40.1	15.1	47.9	38.4	13.7	1.56	10.9	9.2	3.9	0.45	62.0	32.1	1.3	1.8	1.8	0.7	0.5	395
26.00	42.3	40.4	17.3	45.4	38.4	16.2	1.49	11.0	11.7	4.9	0.42	65.7	29.4	2.7	0.2	0.8	0.4	0.6	473
27.00	61.0	22.5	16.5	64.3	19.8	15.9	4.65	11.5	20.6	8.7	0.38	64.4	27.4	0.3	5.2	1.0	1.6	0.0	306
28.00	30.3	31.0	38.7	32.9	29.8	37.2	1.62	11.0				65.0	28.1	0.6	3.1	1.3	1.9	0.0	317
29.00	32.6	34.0	33.4	35.6	32.2	32.2	1.56	11.1	19.3	8.0	0.17	68.5	27.7	0.3	2.7	0.0	0.8	0.0	375

77 SR 3

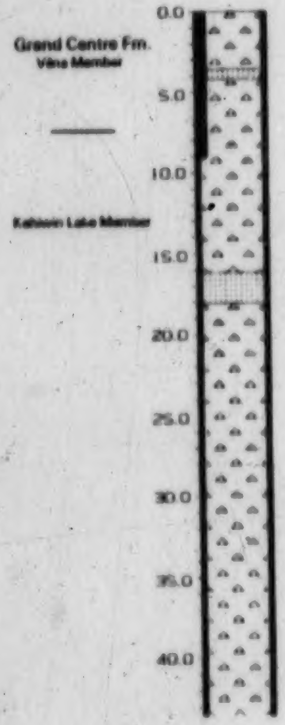
Alberta Geological Survey Testhole 77 SR 3
Location of LSD 16 Sec 10 Twp 58 Rng 10 W of 4 Mer NTS 73L
Elevation 2130 Ft. 649 M Source 1:50,000 NTS 73L/3
Date drilled 197707 22 Logged by: M. FENTON



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOF	OTH	N
1.00								14.3	35.9	15.1	0.11	68.3	26.9	0.7	2.4	0.9	0.7	0.0	423
2.00	38.9	36.7	24.4	41.5	38.1	20.5	1.52	14.3	32.5	13.7	0.40	64.9	28.0	0.5	1.8	3.9	0.8	0.0	382
3.00	36.5	41.2	22.3	39.0	42.0	19.0	1.53	13.7	23.6	9.9	0.24	68.5	25.3	1.0	2.9	1.5	0.8	0.0	517
4.00	32.7	38.3	29.0	35.1	40.1	24.8	1.26	14.2	21.4	9.0	0.40	65.1	25.2	1.5	1.9	3.1	3.1	0.0	321
5.00	36.3	38.9	24.8	38.7	40.2	21.1	1.65	15.2	21.3	8.9	0.18	64.9	27.9	1.5	2.6	3.0	0.0	0.0	265
7.00								12.3	19.1	8.0	0.21	60.0	31.4	0.3	4.7	3.0	0.5	0.0	363
8.00	40.5	37.3	22.1	43.1	39.2	17.7	2.39	10.6	22.4	9.4	0.24	63.8	30.3	0.2	2.8	1.6	1.2	0.0	426
9.00	41.5	37.3	21.2	44.4	38.6	17.0	2.87	10.7	22.1	9.2	0.21	64.3	28.6	0.0	3.9	1.8	1.1	0.3	280
10.00								11.4	22.7	9.5	0.29	59.1	31.2	0.3	3.6	3.9	1.5	0.3	330
11.00	41.3	38.0	20.7	44.0	39.3	16.7	2.51	11.0	19.2	8.0	0.24	56.3	33.7	0.8	4.2	2.9	1.5	0.4	474
12.00								11.6	22.1	9.2	0.22	60.8	31.8	0.0	2.2	3.4	1.4	0.3	355
13.00	41.6	37.0	21.4	44.9	37.9	17.2	2.62	11.1	22.2	9.3	0.26	60.3	30.7	0.0	2.3	4.1	2.1	0.5	388
14.00								10.9	23.0	9.6	0.22	62.2	29.9	1.0	2.6	2.9	1.4	0.0	415
15.00	44.2	36.4	19.4	47.0	38.2	14.8	1.87	10.2	22.3	9.3	0.19	62.2	31.7	0.5	2.4	1.9	1.0	0.2	416
16.00								10.7	22.7	9.5	0.23	59.7	31.7	0.4	2.6	4.1	1.5	0.0	268
17.00	41.4	37.5	21.1	44.1	38.6	17.2	2.43	10.6	22.0	9.2	0.24	58.9	33.5	0.6	2.3	2.3	2.3	0.0	514
18.00								10.4	27.2	11.5	0.38	59.1	35.6	0.3	1.4	2.4	1.0	0.0	286
19.00	41.1	38.4	20.5	43.8	39.9	16.3	2.35	10.3	23.3	9.8	0.46	57.5	33.1	0.7	4.5	2.2	1.5	0.4	266
20.00								10.4	23.9	10.1	0.50	58.6	31.6	0.3	5.7	2.9	0.7	0.0	278
21.00	42.6	37.8	19.6	45.1	41.0	13.9	2.51	10.0	21.2	9.0	0.53	59.2	33.4	0.0	2.4	3.8	0.8	0.3	368
22.00								10.1	24.1	10.1	0.28	59.6	31.7	1.4	2.8	3.8	0.7	0.0	287
23.00	42.5	38.3	19.1	45.1	41.6	13.2	2.63	10.3	23.8	10.0	0.40	61.9	30.6	0.6	2.6	3.6	1.3	0.0	307
24.00								10.6	27.5	11.5	0.24	67.1	25.8	0.6	1.5	3.7	1.2	0.3	322
25.00	40.1	40.1	19.9	42.6	43.6	13.7	1.98	10.1	28.9	12.1	0.24	61.6	32.4	0.8	1.9	3.2	0.3	0.0	370
26.00								10.5	30.5	12.8	0.26	65.3	28.0	0.0	1.5	4.1	1.1	0.0	268
27.00	36.6	42.8	20.6	39.2	46.2	14.6	1.83	10.8	26.9	11.1	0.11	63.5	26.3	0.5	4.5	4.0	1.2	0.0	403
28.00	38.7	42.7	18.6	41.5	45.9	12.6	1.96	10.2	29.5	12.3	0.21	67.9	25.5	0.4	0.8	4.9	0.4	0.0	471
30.00	50.9	31.8	17.2	53.5	33.7	12.9	2.67	9.7	5.9	2.5	1.67	61.3	37.7	0.2	0.2	0.5	0.7	0.0	424
31.00	51.8	32.8	15.4	54.5	33.2	12.3	2.51	11.1	12.4	5.3	0.63	58.9	34.1	1.5	3.1	0.4	1.9	0.0	258
32.00	50.0	34.5	15.6	52.6	35.3	12.1	2.91	11.0	11.2	4.8	0.68	50.3	44.7	0.8	2.2	0.3	1.7	0.0	358
33.50								10.9	12.7	5.4	0.58	52.5	42.9	1.1	1.4	0.6	1.7	0.0	354
34.00	48.4	34.0	17.6	51.0	35.1	13.9	2.66	11.0	12.4	5.3	0.68	60.0	36.4	0.6	1.2	0.9	0.9	0.0	335
35.00								11.1	11.6	4.9	0.34	52.5	43.2	0.3	1.1	0.7	2.1	0.0	280
36.50	46.6	38.3	15.1	49.4	41.3	9.3	2.36	10.1	15.2	6.4	0.30	47.9	44.5	3.0	1.1	1.9	0.0	1.5	263
37.00								10.5	14.9	6.3	0.37	52.6	41.6	0.7	1.9	0.0	2.2	0.0	271
38.00	47.3	40.3	12.4	50.2	42.4	7.3	2.01	9.9	15.3	6.4	0.32	50.2	44.2	1.1	1.5	2.2	0.7	0.0	269
39.50								10.1	15.9	6.6	0.24	51.4	41.8	2.1	2.5	0.7	1.4	0.0	282
40.00	46.4	39.1	14.5	49.3	42.1	8.5	2.19		15.3	6.4	0.27	48.6	43.8	0.2	4.1	2.3	0.7	0.2	436
41.00								11.2	13.4	5.6	0.27	45.8	51.0	0.4	1.3	0.4	1.0	0.0	474
42.50	44.5	41.0	14.5	47.4	44.0	8.6	2.69	10.0	15.4	6.4	0.30	41.6	51.3	1.3	2.6	2.9	0.3	0.0	310
44.00								10.9	14.7	6.2	0.30	52.9	40.1	1.0	3.1	2.1	1.0	0.0	289
46.00	46.9	40.5	12.5	49.8	42.9	7.3	2.00	10.7	13.7	5.7	0.29								
47.00								10.2	16.1	6.7	0.29	50.7	42.3	1.7	2.0	2.0	1.1	0.0	345
48.00	47.4	38.6	14.0	50.3	41.5	8.2	2.08	10.5	16.3	6.8	0.23	51.8	36.6	1.4	7.5	1.9	0.5	0.2	413

77 SR 4

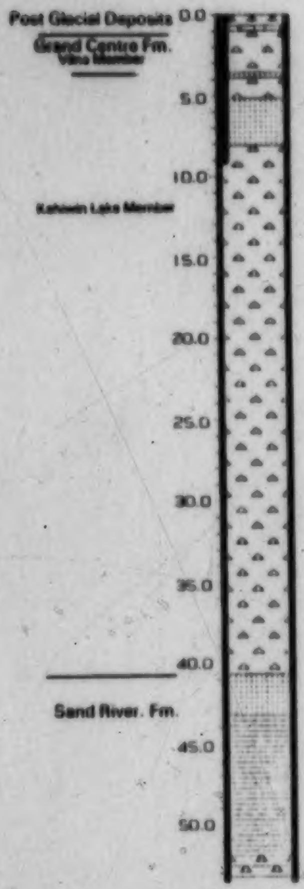
Alberta Geological Survey Testhole 77 SR 4
Location of LSD 13 Sec 14 Twp 58 Rng 11 W of 4 Mer NTS 73L
Elevation 2095 Ft 639 M Source 1 50,000 NTS 73L/4
Date drilled 197707 23 Logged by C LUTZAK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	IDK	OTH	N
1.00								12.4				71.1	21.5	1.0	3.8	2.2	0.3	0.0	312
2.00	35.7	39.1	25.2	38.4	40.2	21.4	1.08	12.2				71.3	22.7	0.2	3.0	2.1	0.7	0.0	432
3.00	35.1	39.9	25.0	37.8	41.1	21.1	1.07	13.5				64.5	26.3	0.3	2.2	3.3	3.0	0.3	361
4.00	29.0	40.2	30.8	31.1	42.4	26.5	1.04	12.6				71.5	21.0	1.9	2.3	2.6	0.7	0.0	428
5.00								12.7				70.5	20.3	0.7	2.0	3.1	1.1	0.0	491
6.00	36.9	37.5	25.6	39.6	39.4	21.0	1.99	11.9				71.1	23.1	1.7	1.0	2.4	1.0	0.0	294
7.00								11.1				69.4	24.8	0.0	2.9	4.6	1.1	0.0	523
8.00	46.7	31.9	21.4	49.3	34.0	16.8	2.87	10.9				70.6	22.5	0.9	2.5	2.9	0.5	0.0	551
9.00	44.0	33.9	22.2	46.5	35.2	18.4	2.57	11.1				75.3	18.4	0.0	3.9	1.8	0.7	0.0	283
10.00								10.5				74.8	19.8	1.5	1.5	2.4	0.3	0.0	338
11.00	45.1	37.8	17.2	47.8	41.3	10.9	2.64	10.8				70.7	24.6	0.2	2.9	1.2	0.2	0.0	410
12.00								11.1				70.3	23.4	0.2	1.2	3.3	1.2	0.2	397
13.00	46.0	36.0	18.0	48.7	39.8	11.4	1.76	10.5				63.2	29.6	0.3	3.4	2.9	0.5	0.0	378
14.00								9.9				63.3	32.1	0.6	2.1	0.9	0.9	0.0	330
15.00	48.9	36.3	14.8	51.3	38.8	9.8	2.64	9.9				71.9	23.4	0.0	1.4	2.9	0.3	0.0	278
15.50								9.3				63.6	27.8	1.5	3.0	3.0	1.0	0.0	396
18.00	44.6	36.8	18.5	47.3	40.5	12.2	2.68	11.1				63.1	28.0	0.0	4.4	3.7	0.7	0.0	293
19.00								10.6				66.0	24.4	0.5	2.7	4.3	1.6	0.3	368
20.00	43.3	36.0	20.7	45.9	38.8	15.3	2.46	10.9				63.6	27.1	2.8	3.8	1.7	1.0	0.0	398
21.00								11.1				68.1	23.8	1.0	3.3	2.6	1.3	0.0	307
22.00	43.9	37.0	19.1	46.5	40.4	13.1	2.56	10.6				61.5	29.9	0.4	4.0	2.5	1.7	0.0	478
23.00								10.4				64.5	28.5	0.2	3.4	3.0	0.4	0.0	439
24.00	44.2	36.9	18.9	46.8	40.0	13.2	2.30	10.4				67.1	26.2	0.4	2.4	1.8	1.0	1.0	496
25.00								10.3				68.7	23.3	0.4	4.1	2.2	1.2	0.0	492
26.00	43.9	36.8	19.4	46.6	40.2	13.3	2.34	10.4				62.0	31.6	0.0	0.9	4.4	1.2	0.0	342
27.00								10.4				63.7	29.0	1.1	2.8	2.2	1.1	0.0	355
28.00	47.1	37.7	19.1	45.7	41.3	12.9	2.52	10.7				63.7	29.5	0.0	2.1	3.6	0.6	0.6	336
29.00								10.5				68.0	25.8	0.4	2.5	1.6	1.4	0.4	441
30.00	44.0	36.8	19.2	46.7	39.5	13.8	2.46	10.2				62.[illegible]	27.5	0.8	3.9	4.1	1.0	0.2	386
31.00								10.9				65.8	27.7	0.0	2.5	2.5	1.4	0.0	278
32.00	43.6	38.3	18.1	46.3	40.7	13.0	2.41	10.2				65.9	27.4	0.5	1.6	4.0	0.5	0.0	372
33.50								10.3				65.7	26.6	0.4	3.4	2.9	0.9	0.0	440
34.00	44.0	39.4	16.7	46.7	41.1	12.2	2.58	10.2				61.4	31.4	0.3	2.7	3.3	0.5	0.5	361
35.00								10.1				66.8	26.3	0.3	1.6	3.1	1.8	0.0	381
36.00	44.6	38.9	16.5	47.3	41.7	11.0	2.45	10.1				59.7	29.5	0.5	5.0	5.0	0.0	0.5	400
37.00								10.9				67.4	26.8	0.5	2.3	2.6	0.3	0.0	384
38.00								9.9				69.3	23.9	1.1	3.2	2.1	0.3	0.0	372
39.50								9.6				63.3	29.3	0.3	3.7	2.5	0.6	0.3	352
40.00								10.2				66.1	27.3	0.7	2.2	2.9	0.7	0.0	407
41.00								10.0				67.1	27.0	0.0	[illegible]	2.5	0.5	0.3	359
42.50								9.0				66.7	28.0	0.7	1.2	1.9	1.4	0.0	414
43.00								11.4				63.5	28.7	0.7	1.9	2.4	0.7	0.0	421

77 SR 5

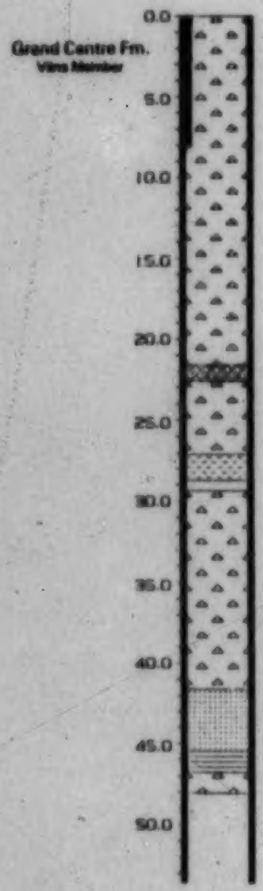
Alberta Geological Survey Testhole 77 SR 5
Location of LSD. 3 Sec 26 Twp 59 Rng 13 W of 4 Mer. NTS 73L
Elevation 2100 FT 640 M Source 1 50,000 NTS 73L/4
Date drilled 197707 24 Logged by M FENTON



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC-SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/MG	IGN MEIN	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00	38.3	24.5	37.2	40.8	28.5	30.8	1.55	18.4				64.2	26.3	0.0	2.2	2.9	4.4	0.0	137
3.00	38.6	23.6	37.7	41.2	28.2	30.7	1.49	15.2				58.1	33.5	0.6	3.9	1.9	1.9	0.0	155
4.00	48.8	23.0	28.1	51.1	25.8	23.1	1.95	14.4				59.7	32.7	0.0	4.7	2.0	0.9	0.0	211
5.00	48.6	22.0	28.4	51.3	23.5	25.2	2.05	13.3				55.6	34.5	0.4	3.4	3.4	2.6	0.0	232
9.00	44.9	26.4	28.7	47.6	32.1	20.3	1.85					62.9	30.6	0.0	3.5	1.2	1.8	0.0	170
11.00	46.1	25.3	28.4	49.7	31.2	19.6	2.09					61.2	32.1	0.6	2.8	1.8	1.2	0.3	327
12.00								12.0											
13.00	45.3	26.0	28.7	47.9	32.7	19.4	2.06	12.6				53.1	37.4	1.7	2.4	3.8	1.4	0.0	289
14.00								11.9											
15.00	45.1	24.4	30.6	47.9	30.6	21.5	2.18	11.8				60.5	31.5	0.2	3.8	1.8	2.0	0.0	451
16.00								11.7											
17.00	46.3	24.3	29.5	48.9	30.5	20.5	2.19	11.4				56.6	35.5	0.4	2.8	2.6	1.9	0.4	468
18.00								10.8											
19.00	47.5	23.8	28.7	50.2	29.5	20.3	2.19	10.5				61.1	27.1	0.3	3.1	3.7	4.6	0.0	350
20.00								10.7											
21.00	46.2	26.4	27.5	48.8	31.6	19.7	2.12	10.4				62.7	27.9	0.6	2.0	3.4	2.8	0.2	501
22.00								11.2											
23.00	47.3	26.9	25.8	50.0	32.2	17.8	2.24	10.5				59.0	31.9	0.9	3.8	2.7	1.8	0.0	339
24.00								10.6											
25.00	46.1	28.3	25.6	49.1	33.4	17.6	2.39	10.4				66.7	25.1	0.0	4.3	2.8	1.2	0.0	327
26.00								10.5											
27.00	47.5	24.1	28.4	50.0	29.6	20.4	2.27	10.8				61.2	31.0	0.3	2.6	1.8	3.1	0.0	381
28.00								10.1											
29.00	50.4	23.6	26.0	53.3	28.2	18.5	2.40	10.2				56.4	31.1	0.0	4.1	4.4	3.7	0.3	296
30.00								9.9											
31.00	46.5	27.3	26.1	49.2	32.9	17.9	3.12	10.5				63.4	27.9	1.1	1.5	3.2	1.5	0.2	473
32.00								9.7											
33.50	44.7	24.9	30.4	47.2	31.8	21.0	2.28	10.4				63.0	29.6	0.0	2.5	2.5	2.9	0.0	513
34.00								10.8											
35.00	44.5	27.9	27.7	47.0	34.0	19.0	1.98	10.8				60.1	31.6	0.0	3.0	3.2	2.3	0.0	434
36.00								10.4											
37.00	43.9	26.2	29.9	47.0	31.0	22.0	1.82	10.5				61.2	29.9	1.3	3.1	3.6	0.8	0.0	384
38.00								10.7											
39.50	38.2	24.8	37.0	40.6	28.4	31.1	1.15	12.2				67.2	28.2	0.0	1.1	3.4	0.0	0.0	177
40.00								18.4											
43.00								16.4											
44.00								19.0											
46.00								19.4											
47.00								19.2											
48.00								20.0											
49.00								20.8											
50.00								19.5											
51.00								20.1											
52.00	5.9	23.9	70.2	6.8	35.3	57.9	0.23	17.5				55.1	38.3	4.1	2.1	0.0	0.0	0.0	47
53.00	1.4	41.6	57.0	1.9	59.2	38.9	0.00	20.0											
54.00	3.4	48.4	48.2	4.3	60.0	35.7	0.04	21.6											

77SR6

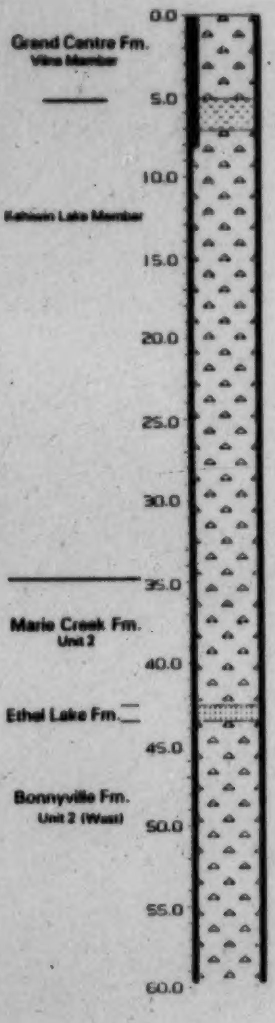
Alberta Geological Survey Testhole 77 SR 6
Location of LSD 9 Sec 23 Twp 58 Rng 13 W of 4 Mer . NTS 73L
Elevation 2130 Ft 649 M Source 1 50,000 NTS 73L/4
Date drilled 197707 25 Logged by C LUTZAK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								14.3											
2.00	28.2	44.2	27.6	31.2	46.0	22.9	0.82	14.7				66.0	18.9	1.9	6.6	2.8	1.9	1.0	106
3.00	35.0	41.1	23.9	37.6	42.7	19.7	1.03	12.7				78.9	12.3	0.9	5.3	0.9	1.8	0.0	114
4.00	36.5	38.5	25.0	39.4	40.0	20.7	1.10	16.1				62.9	22.9	1.9	4.8	5.7	1.9	0.0	105
5.00								16.6											
6.00	29.6	41.3	29.1	31.9	42.3	25.9	0.83	17.6				61.7	23.4	0.0	5.6	5.6	3.7	0.0	107
7.00								17.9											
8.00	36.3	39.5	24.1	39.9	41.8	18.4	1.80	15.1				70.6	20.9	1.4	1.4	4.3	1.4	0.0	211
9.00								16.7											
10.00	35.8	41.6	22.7	38.5	43.9	17.6	1.64	14.7				62.8	28.1	0.0	3.6	3.6	2.0	0.0	196
11.00								16.8											
12.00	31.4	41.0	27.6	33.6	45.7	20.7	2.10	14.0				75.7	17.6	0.0	1.8	4.8	0.0	0.0	227
13.00	34.6	42.1	23.4	37.4	44.6	18.0	1.34	14.0				71.7	25.4	0.6	1.7	0.0	2.3	0.0	173
14.00	38.1	41.1	20.5	41.3	42.7	15.9	1.54	12.8				75.6	19.2	0.0	1.0	2.6	1.6	0.0	193
15.00	37.5	39.6	22.8	40.4	41.8	17.8	1.68	10.9				74.5	18.4	1.5	3.6	2.0	0.0	0.0	196
16.00								11.0											
17.00	35.7	41.4	22.9	38.5	43.4	18.1	1.57	15.9				74.2	21.5	0.0	0.5	3.2	0.5	0.0	186
18.00								11.7											
19.00	37.9	38.6	23.4	40.8	41.2	18.0	2.00	10.8				78.1	17.3	0.0	1.3	3.4	0.0	0.0	237
20.00								12.0											
21.00								20.0											
22.00								18.8											
23.00								13.4											
24.00	31.1	41.9	27.0	33.3	44.7	22.1	1.29	14.5				65.8	23.9	0.6	3.2	6.5	0.0	0.0	155
25.00	29.7	41.8	28.4	31.9	45.4	22.7	1.30	14.7				68.8	20.4	0.0	5.1	4.5	0.6	0.6	157
26.00	29.3	41.9	28.9	31.4	45.7	22.9	1.29	14.5				62.6	22.6	3.2	5.2	4.5	1.3	0.6	155
27.00								16.0											
28.00								14.7											
29.00								15.1											
30.00								11.0											
31.00	27.8	46.6	25.6	30.6	51.5	17.9	0.74	12.8				56.8	31.6	1.1	1.1	9.5	0.0	0.0	95
32.00								10.2											
33.00	35.8	44.1	20.1	38.9	47.4	13.8	0.83	10.6				64.4	28.7	1.0	1.0	3.0	2.0	0.0	101
34.00								14.3											
35.00	14.9	55.4	29.7	17.4	61.4	21.1	0.29	13.6				84.4	13.3	0.0	2.2	0.0	0.0	0.0	45
36.00								14.7											
37.00	20.4	51.6	28.0	22.6	57.4	20.0	0.66	12.4				54.7	29.3	10.7	5.3	0.0	1.3	0.0	75
38.00								10.3											
39.00	33.7	42.3	24.0	36.1	47.7	16.2	0.97	10.1				69.7	25.2	1.7	0.8	0.0	2.5	0.8	119
40.00	41.1	40.4	18.5	41.8	46.3	11.8	3.70	10.0				78.0	17.9	1.6	0.0	1.6	0.8	0.0	123
41.00	24.2	45.0	30.8	26.5	52.4	21.1	0.39	12.9				71.4	22.4	4.1	0.0	2.0	0.0	0.0	49
46.00																			
47.00	35.7	43.5	20.8	38.1	49.0	12.9	0.94	11.8				66.1	24.0	0.0	5.0	2.5	2.5	0.0	121
48.00								15.5											
49.00								20.2											
50.00								21.9											
51.00								16.6											

77 SR 7

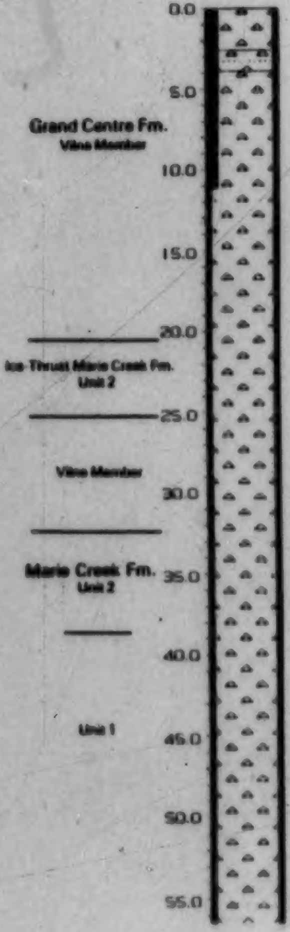
Alberta Geological Survey Testhole 77 SR 7
Location NE of LSD 16 Sec 29 Twp 59 Rng 11 W of 4 Mer. , NTS 73L
Elevation 2130 Ft 649 M Source 1 50,000 NTS 73L/4
Date drilled 197707 27 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								23.3				68.0	28.7	2.5	0.0	0.0	0.7	0.0	275
2.00	26.9	23.8	49.3	29.2	31.6	39.3	1.16	14.9				64.3	30.8	0.7	2.1	1.4	0.7	0.0	143
3.00	29.3	29.6	41.1	31.8	36.1	32.1	0.00	10.7				59.6	35.1	0.3	2.6	1.7	0.6	0.0	347
4.00	30.9	32.4	36.7	33.3	38.4	28.3	1.32	18.1				66.7	19.6	2.0	3.9	3.9	3.9	0.0	51
5.00	42.1	27.4	30.5	44.7	31.3	24.0	2.08	10.8				65.6	30.3	0.3	1.4	1.7	0.7	0.0	294
6.00								12.3				56.1	39.5	0.0	2.6	1.7	0.0	0.0	114
7.00	46.5	23.2	30.3	49.2	27.0	23.8	2.47	10.9				61.0	30.9	1.2	1.5	4.0	1.2	0.0	323
8.00	48.5	22.9	28.6	51.1	26.0	22.9	2.46	11.7				58.3	31.9	1.0	3.7	3.2	2.0	0.0	408
9.00	49.6	22.7	27.7	52.3	26.2	21.5	2.58	10.2				57.2	38.8	0.6	0.0	1.6	1.6	0.0	484
10.00								10.1				59.4	33.7	0.8	0.8	3.3	1.9	0.0	362
11.00	45.6	30.4	24.0	48.3	35.3	16.4	2.35	10.5				62.1	29.0	1.0	2.9	4.2	0.5	0.3	383
12.00								10.3				59.5	32.0	0.8	3.6	1.3	2.8	0.0	390
13.00	47.3	31.6	21.1	50.0	35.9	14.2	2.01	12.0				56.8	33.8	0.3	3.6	4.2	1.3	0.0	308
14.00								9.4				56.9	35.9	1.3	0.3	1.0	1.0	0.0	295
15.00	49.2	31.0	19.8	51.9	35.5	12.7	2.20	12.6				56.9	36.6	0.0	3.2	3.2	1.0	0.0	311
16.00								10.0				58.0	33.3	1.1	2.9	3.3	1.4	0.0	276
17.00	48.7	30.7	20.6	51.4	35.5	13.0	1.96	9.3				59.9	30.9	0.3	3.7	3.4	1.5	0.0	324
18.00								11.8				63.8	29.8	0.3	1.3	2.6	1.6	0.6	312
19.00	49.6	26.7	23.6	52.3	32.0	15.7	2.30	9.9				61.4	36.3	0.0	1.1	0.4	0.7	0.0	267
20.00								9.6				59.0	31.9	0.3	2.8	2.5	3.1	0.3	354
21.00	47.9	26.9	25.2	50.5	32.4	17.1	2.12	11.0				54.2	36.7	0.4	3.4	2.7	2.3	0.2	441
22.00								10.4				55.4	37.2	0.3	3.3	3.0	0.8	0.0	368
23.00	47.2	29.2	23.6	49.9	34.4	15.7	2.02	10.1				54.9	37.1	0.3	2.9	2.4	2.1	0.3	377
24.00								11.2				53.1	35.7	0.9	4.2	4.2	1.5	0.3	333
25.00	47.2	27.5	25.3	50.5	32.0	17.5	1.78	11.6				55.3	37.9	0.5	1.9	2.2	2.2	0.0	367
26.00								11.7				58.0	33.3	0.7	5.3	1.7	1.0	0.0	300
27.00	49.0	26.8	24.2	51.8	32.9	15.3	1.81	10.5				56.1	34.9	0.7	3.9	2.8	1.4	0.2	433
28.00								10.7				57.8	36.1	0.7	3.2	0.7	1.4	0.2	438
29.00	47.7	28.4	23.9	50.8	33.2	15.9	2.30	10.3				56.1	33.2	0.7	3.8	4.9	1.2	0.0	424
30.00								10.6				54.1	38.9	0.7	3.6	2.7	0.0	0.0	442
31.00	46.0	31.4	22.7	48.7	36.4	14.9	2.20	10.9				57.6	34.3	0.5	4.6	1.4	1.6	0.0	434
32.00								10.7				55.1	37.6	0.9	3.8	2.0	0.7	0.0	452
33.00	47.3	30.0	22.6	50.4	35.0	14.6	2.35	10.9				53.4	38.5	0.9	3.4	2.5	1.3	0.0	442
34.00								10.4				55.3	34.9	0.8	3.2	4.9	0.8	0.0	472
35.00	50.2	30.8	18.9	53.0	34.7	12.4	2.53	10.2				64.3	29.0	1.0	0.7	3.5	1.0	0.3	286
36.00								10.1				62.1	30.1	1.0	2.3	4.0	0.4	0.0	472
37.00	42.5	28.4	29.1	44.9	34.8	20.3	2.17	9.3				63.4	28.8	0.6	1.8	4.2	1.0	0.2	500
38.00								10.5				59.3	32.6	1.9	1.9	3.2	1.1	0.0	374
39.00	39.8	27.6	32.6	42.2	32.9	24.9	2.12	10.1				61.6	26.1	1.6	2.1	6.8	1.8	0.0	383
40.00								10.4				63.3	27.6	0.8	1.9	5.6	0.8	0.0	376
41.00	38.9	30.2	29.9	42.4	36.7	20.9	2.06	10.6				61.6	26.7	1.1	3.3	5.5	1.5	0.2	453
42.00								10.4				63.1	23.1	1.5	3.7	6.5	1.8	0.3	325
44.00	29.4	39.8	30.8	32.2	47.0	20.8	1.42	12.8				48.9	36.4	0.7	6.9	4.2	2.4	0.3	288
45.00								12.9				44.7	42.1	0.0	4.5	4.9	2.6	1.1	266
46.00	32.5	37.9	29.6	35.7	44.8	19.4	1.60	11.9				56.5	35.2	0.7	4.3	0.3	2.5	0.3	273
47.00								11.7				54.4	31.8	0.3	4.5	4.2	4.2	0.5	377
48.00	39.0	34.8	26.2	39.8	43.1	17.1	1.23	13.3				51.2	35.6	2.7	1.9	3.5	4.8	0.3	371
49.00								11.5				51.0	40.0	0.7	3.2	2.9	2.4	0.0	410
50.00	33.2	35.2	31.6	35.9	42.9	21.2	1.39	12.2				51.6	39.7	0.5	4.4	1.9	1.6	0.0	365
51.00								12.5				49.0	40.3	1.1	4.2	2.7	2.3	0.4	263
52.00	31.3	33.1	35.5	34.1	41.8	24.2	1.27	12.7				51.7	37.6	0.4	5.2	2.6	1.8	0.7	271
53.00								10.8				57.2	36.4	1.2	1.8	0.9	2.1	0.3	332
54.00	40.6	31.3	28.1	43.1	38.8	18.1	2.06	11.3				52.1	38.2	0.7	4.2	3.5	1.2	0.0	424
55.00								13.4											
56.00	39.1	29.4	31.5	41.9	37.2	20.9	1.53	10.8				56.0	35.6	1.6	3.1	2.3	1.3	0.0	382
57.00								11.6				52.3	35.5	0.6	6.0	2.0	3.4	0.0	352
58.00	38.1	38.2	23.7	40.6	44.2	15.1	1.59	11.9				56.4	36.9	0.5	1.7	2.5	1.9	0.0	358
59.00	38.5	32.0	29.5	41.3	39.1	19.6	1.52	11.5				61.4	32.1	1.2	2.2	1.5	1.2	0.3	324
60.00	36.1	39.1	24.8	38.8	45.9	15.3	1.35	10.9				59.7	32.8	0.9	2.8	1.8	1.8	0.0	323

77SR8

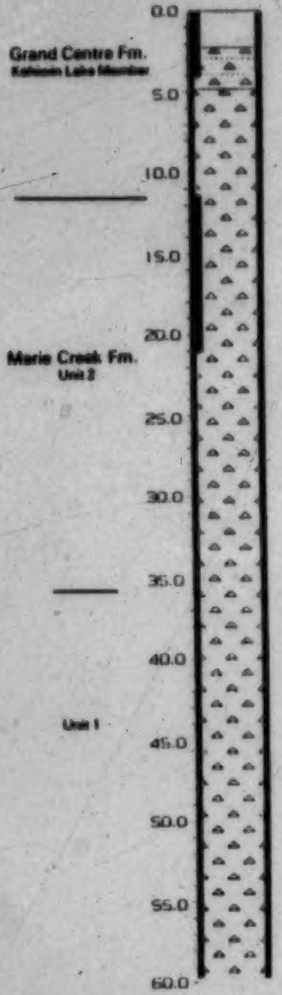
Alberta Geological Survey Testhole 77 SR 8
Location SE of LSD 11 Sec 25 Twp 61 Rng 11 W of 4 Mer . NTS 73L
Elevation 2150 Ft 656 M Source 1 50,000 NTS 73L/5
Date drilled 197707 28 Logged by M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LSI	DSI	LOC	OTH	N
1.00	26.1	35.1	38.8	28.8	38.5	32.7	0.90	14.1				69.3	27.4	0.8	0.8	1.3	0.2	0.2	521
2.00	34.9	30.7	34.4	37.2	35.1	27.7	1.20	16.5				54.0	31.5	2.7	6.3	2.7	1.8	0.0	111
3.00								12.8				59.6	26.1	2.7	4.8	5.9	0.8	0.0	371
4.00	32.9	25.1	42.1	35.3	29.3	35.3	0.86	13.7				61.0	28.7	2.1	1.2	5.5	1.2	0.2	421
5.00	32.4	28.6	39.1	34.9	32.1	33.0	1.07	14.0				59.2	29.9	1.5	4.0	3.7	1.5	0.0	321
6.00	35.3	27.6	37.1	37.8	30.9	31.3	1.10	12.8				54.9	35.4	0.9	3.7	2.3	1.7	1.0	570
7.00	36.3	27.6	36.0	38.9	29.9	31.2	1.12	11.3				53.6	35.7	1.7	3.6	4.4	1.0	0.0	412
8.00	37.0	28.7	34.3	39.5	31.6	28.9	1.10	11.7				58.4	34.2	2.2	1.9	1.5	1.8	0.0	322
9.00												56.5	31.4	0.5	4.3	5.8	1.4	0.0	414
10.00	33.7	27.8	38.5	36.2	33.4	30.3	1.23	12.0				59.2	31.2	0.6	2.0	5.9	0.9	0.0	304
11.00								11.6				60.0	30.3	0.8	3.5	3.8	0.7	0.3	597
12.00	30.4	26.1	43.6	32.6	33.0	34.5	1.58	12.1				59.5	26.7	1.3	5.8	5.1	1.4	0.0	583
13.00								11.9				58.7	30.6	1.0	3.6	4.2	0.4	0.2	497
14.00	36.9	29.3	33.7	39.5	22.8	37.8	1.14	13.3				56.8	35.3	1.4	3.5	2.1	[illegible]	0.0	433
15.00								13.6				62.8	29.1	0.4	3.4	2.8	0.8	0.2	463
16.00	27.7	30.2	42.1	29.8	23.0	47.2	1.08	12.5				61.2	28.4	0.6	2.0	4.5	2.6	0.0	510
17.00								12.9				63.3	29.0	1.5	2.5	3.1	0.6	0.0	325
18.00	32.0	33.4	34.6	47.2	13.5	39.3	0.88	11.2				61.4	32.2	2.0	1.7	2.0	0.6	0.0	298
19.00	27.3	36.3	36.4	30.0	29.1	40.9	0.82	12.4				59.4	29.8	0.9	3.2	3.2	3.2	0.3	315
20.00	29.9	33.1	37.0	32.7	26.6	40.7	0.80	10.8				50.3	37.8	0.6	6.2	4.7	0.3	0.0	320
21.00	31.0	32.0	37.0	33.2	25.7	41.1	2.11	11.0				61.4	26.6	0.2	1.8	8.3	1.5	0.0	443
22.00	31.2	39.9	28.9	33.5	32.6	33.9	1.82	10.5				51.8	27.0	1.1	3.6	12.1	1.5	0.0	356
23.00	30.7	38.7	30.6	33.0	31.3	35.7	1.83	10.1				57.3	24.6	0.3	2.1	13.0	2.1	0.3	337
24.00	31.5	37.5	31.1	33.8	30.4	35.8	2.04	9.8				56.0	28.1	0.7	3.5	10.8	0.9	0.0	427
25.00	33.3	35.0	31.8	36.3	27.9	35.7	0.75	8.8				57.0	34.0	1.5	3.1	1.5	1.8	0.0	323
26.00	29.0	33.6	37.4	31.6	26.7	41.8	0.60	11.5				56.7	32.3	1.8	5.5	0.9	2.4	0.5	217
27.00								10.8				68.3	24.6	2.0	0.7	2.4	1.6	0.2	407
28.00	22.6	39.2	38.3	24.5	32.4	43.0	0.58	12.0				50.0	36.8	2.0	4.0	5.0	11.6	0.0	298
29.00								12.5				68.8	22.4	0.4	2.7	5.6	0.0	0.0	478
30.00	9.8	57.0	33.2	12.4	50.3	37.3	0.88	12.2				61.9	28.6	0.6	3.0	4.9	0.9	0.0	328
31.00								12.1				58.7	31.3	3.0	2.1	3.3	0.9	0.6	329
32.00	26.8	39.1	34.0	29.4	32.1	38.5	0.89	11.2				68.9	23.9	0.0	1.4	5.3	0.5	0.0	360
33.00	34.3	39.7	26.0	36.8	33.8	29.4	2.19	9.8				66.5	15.2	0.6	3.9	13.0	0.9	0.0	361
34.00	30.7	40.4	28.8	32.7	34.1	33.2	1.94	10.3				71.8	22.1	0.2	1.0	4.6	0.2	0.0	411
35.00								8.6				55.8	16.2	0.2	5.1	18.9	3.0	0.2	428
36.00	38.3	36.9	24.8	41.3	30.8	27.9	2.61	8.9				47.7	17.4	0.0	7.0	23.9	3.7	0.3	356
37.00								8.4				52.3	14.1	0.2	6.3	19.0	7.8	0.0	411
38.00	12.1	61.8	26.1	14.9	55.4	29.7	2.12	9.6				50.1	20.7	0.0	6.9	18.2	3.6	0.0	363
39.00	28.2	33.8	37.9	30.0	26.8	43.2	1.88	12.1				57.4	29.5	2.4	3.0	6.2	1.5	0.0	336
40.00	26.3	35.4	38.3	28.1	28.8	43.1	1.67	13.2				57.4	27.7	0.4	4.4	8.9	0.8	0.0	472
41.00	34.3	34.1	31.6	36.4	27.4	36.2	1.69	11.7				61.7	27.1	0.0	2.4	8.2	0.5	0.0	376
42.00								11.7				59.8	27.6	0.3	2.5	8.1	1.1	0.0	358
43.00	28.6	36.0	35.4	30.4	29.7	39.9	1.59	12.9				66.4	24.3	0.6	2.2	5.4	0.9	0.0	313
44.00								10.4				62.1	22.3	0.9	3.7	9.8	0.6	0.0	327
45.00	17.3	51.8	30.8	19.6	46.0	34.4	1.87	10.5				68.0	22.7	1.0	3.1	4.7	0.4	0.0	488
46.00								10.7				61.9	26.3	0.0	2.5	8.8	0.6	0.0	365
47.00	34.6	35.7	29.7	37.0	28.9	34.1	2.03	10.7				64.9	21.2	0.9	1.8	10.5	0.6	0.0	325
48.00								10.4				68.9	21.7	0.3	1.4	6.4	1.3	0.0	360
49.00	34.2	33.8	32.1	36.4	27.7	36.0	2.37	10.6				63.4	24.9	0.2	3.3	7.4	0.7	0.0	429
50.00								10.0				67.5	23.8	0.5	1.6	5.2	1.0	0.0	382
51.00	37.8	33.1	29.1	40.1	26.7	33.2	2.63	9.8				66.1	25.4	0.0	1.0	6.4	1.0	0.0	511
52.00								10.1				66.5	25.6	0.2	1.7	5.5	0.4	0.0	457
53.00	36.0	35.4	28.6	38.3	29.1	32.5	2.32	9.2				69.9	21.8	0.7	1.1	6.4	0.0	0.0	436
54.00	41.8	32.7	25.4	44.2	26.7	29.2	2.75	9.5				68.6	22.1	0.2	1.7	6.4	0.7	0.0	574
55.00	29.4	35.8	34.8	31.5	29.3	39.1	1.10	11.4				67.5	23.0	0.0	1.9	4.5	2.9	0.0	308
56.00	34.8	34.9	30.4	37.0	28.9	34.1	2.29	10.0				59.2	29.3	0.8	2.5	6.1	2.0	0.0	358

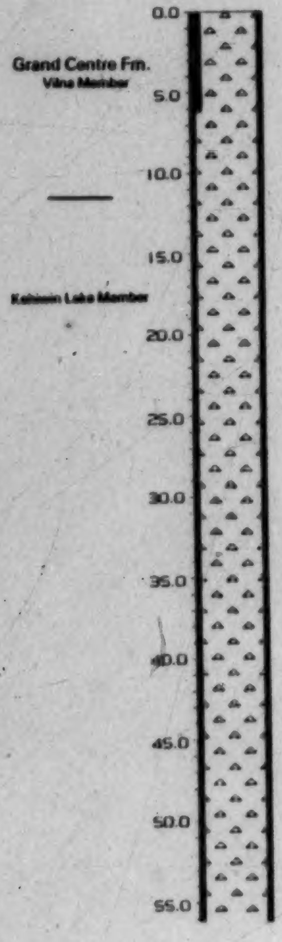
77SR9

Alberta Geological Survey Testhole 77 SR 9
Location NE of LSD 16 Sec 7 Twp 60 Rng 8 W of 4 Mer , NTS 73L
Elevation 2005 ft 611 M Source 1 50,000 NTS 73/3
Date drilled 197708 01 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN META	QTZ	QTZT USS	LST	DST	LOC - OTH	N
3.00	47.1	38.7	14.2	50.5	38.7	10.8	1.14	7.4				66.1	24.2	3.2	1.8	3.4	1.2	0.2	504
4.00																			
5.00	45.6	38.3	16.1	48.6	39.5	11.9	2.05	6.7				68.2	21.3	1.7	2.0	3.8	2.3	0.0	343
6.00	39.4	41.7	18.9	42.0	43.7	14.3	1.13	7.4											
7.00												59.3	23.9	3.3	6.1	4.5	1.9	0.7	423
8.00								7.8				66.2	24.0	1.2	3.6	3.8	1.2	0.0	337
9.00	38.2	42.3	19.4	40.8	44.5	14.7	1.07	8.1				58.8	25.7	2.2	3.8	4.4	4.9	0.4	452
10.00								8.6				63.4	19.8	3.6	6.3	4.7	1.9	0.3	363
11.00	34.9	43.2	22.0	37.5	44.6	17.9	1.22	10.9				69.5	17.3	0.5	3.7	8.1	0.8	0.0	381
12.00	35.0	30.9	34.1	37.4	33.0	29.6	2.18	7.7				69.6	18.5	0.2	2.8	7.2	1.3	0.0	388
13.00	34.9	31.8	33.3	37.4	34.4	28.1	1.99	7.2				72.0	15.8	0.2	3.4	6.9	1.6	0.0	436
14.00	36.4	31.9	31.6	39.0	34.5	26.5	2.28	7.2				62.2	20.3	2.1	12.7	2.1	0.5	0.0	418
15.00	36.2	31.3	32.5	38.7	33.8	27.4	2.39	7.8				66.0	17.7	0.3	3.0	12.5	0.8	0.0	368
16.00								8.3				66.1	20.6	0.0	2.5	9.3	1.2	0.2	431
17.00	35.0	32.3	32.7	37.6	35.4	27.0	2.03	7.7				69.2	15.7	0.3	3.9	10.2	0.8	0.0	383
18.00								8.6				68.4	19.2	0.2	2.9	7.3	2.0	0.0	452
19.00	35.8	31.4	32.8	38.3	34.1	27.5	2.10	8.0				70.1	16.0	0.0	3.7	9.0	1.0	0.2	401
20.00								7.9				69.2	16.5	0.7	3.2	9.7	0.0	0.5	400
21.00	36.7	28.8	34.5	39.2	32.0	28.8	2.20	8.6				71.8	14.6	0.6	3.7	8.5	0.9	0.0	458
22.00								8.6				69.5	16.8	0.4	2.7	10.2	0.4	0.2	482
23.00	35.1	29.6	35.3	37.6	33.0	29.4	2.31	8.7				68.1	17.5	1.4	2.9	9.0	1.2	0.0	411
24.00								7.9				65.7	20.3	0.2	3.8	10.4	0.0	0.0	394
25.00	34.5	30.5	35.0	37.0	33.5	29.5	2.18	8.7				67.7	22.3	0.2	2.2	6.5	1.0	0.0	412
26.00								8.1				64.2	22.8	0.6	3.2	8.0	0.9	0.2	464
27.00	33.9	29.0	37.1	36.3	32.9	30.8	2.24	8.3				69.4	15.4	0.5	3.1	10.7	0.5	0.3	382
28.00								8.6				71.1	19.7	0.0	2.2	6.7	0.0	0.2	401
29.00	32.5	28.9	38.6	34.8	32.9	32.3	2.11	8.5				71.5	18.3	0.3	3.4	6.3	0.3	0.0	382
30.00								6.7				66.9	20.5	0.0	2.2	10.1	0.5	0.0	366
31.00	33.2	28.8	38.0	35.6	32.2	32.2	2.34	8.9				68.6	16.1	0.0	2.0	10.9	2.5	0.0	404
32.00								8.2				65.8	19.4	1.2	3.9	8.1	1.5	0.0	406
33.00	33.8	28.4	37.8	36.2	32.0	31.8	2.08	8.5				67.1	20.2	0.0	2.0	10.2	0.5	0.0	401
34.00								8.9				71.1	17.2	0.5	2.7	6.5	1.9	0.0	367
35.00	31.7	27.7	40.6	34.0	32.5	33.5	2.43	7.0				64.8	24.6	0.0	1.9	7.5	0.8	0.0	358
36.00								7.8				64.3	20.2	0.5	3.1	9.6	1.7	0.5	415
37.00	33.0	28.7	38.2	35.4	32.3	32.3	2.20	8.0				64.6	19.8	0.0	1.7	12.3	1.5	0.0	398
38.00								8.3				64.6	23.2	0.3	2.3	8.7	0.9	0.0	345
39.00	32.6	27.8	39.5	34.9	31.3	33.8	1.94	8.5				65.0	23.7	0.0	2.9	6.6	1.7	0.0	408
40.00								8.9				64.3	18.8	0.6	3.4	10.6	2.3	0.0	350
41.00	29.2	27.6	43.2	31.4	32.1	36.4	1.80	9.3				71.2	18.9	0.3	2.0	6.7	0.9	0.0	344
42.00								9.1				72.7	16.9	0.6	3.2	6.4	0.3	0.0	344
43.00	32.5	25.6	42.0	34.8	29.9	35.4	2.01	9.2				66.5	19.5	0.2	2.8	10.4	0.5	0.0	394
44.00								8.5				66.5	21.9	0.0	3.6	6.7	0.9	0.3	328
45.00	30.5	26.6	42.9	32.8	30.7	36.6	2.06	8.7				64.6	24.6	0.0	3.8	6.2	1.1	0.0	370
46.00								8.4				69.8	17.4	0.6	2.2	8.0	1.9	0.0	311
47.00	27.8	27.8	44.4	30.3	32.5	37.1	1.73	9.0				68.7	17.7	0.3	3.1	7.6	2.4	0.3	288
48.00								8.6				69.9	18.8	0.0	1.4	9.0	0.8	0.0	366
49.00	30.3	28.6	41.2	32.7	32.8	34.6	1.95	8.6				67.0	23.1	0.0	2.7	6.3	0.8	0.0	364
50.00								8.6				63.2	21.9	0.0	4.2	9.1	1.5	0.0	329
51.00	31.1	26.9	42.1	33.5	31.4	35.1	1.88	8.3				67.4	20.7	0.6	3.6	7.0	0.6	0.0	328
52.00								8.5				57.4	30.7	0.9	4.4	10.2	1.3	0.0	225
53.00	29.6	27.3	43.1	31.7	31.8	36.5	2.00	8.6				63.7	20.2	0.6	1.4	10.9	0.9	0.3	322
54.00								14.4				65.4	21.4	1.0	1.7	7.6	0.8	0.0	379
55.00	33.9	29.4	36.7	36.5	32.9	30.6	2.24	10.2				67.5	19.8	0.0	2.9	8.0	1.8	0.3	319
56.00								8.4				61.2	24.0	0.7	2.1	10.6	1.4	0.0	433
57.00	31.4	26.1	42.5	33.6	30.7	35.7	2.30	8.7				64.2	23.7	0.5	1.8	6.6	1.1	0.0	363
58.00	31.6	27.0	41.4	33.9	31.1	35.0	2.06	8.2				67.4	21.4	0.3	1.5	8.7	0.6	0.0	322
59.00	40.2	24.4	35.4	42.3	27.8	29.8	4.34	6.6				66.7	24.6	1.1	2.5	4.5	0.3	0.0	357

77 SR 10

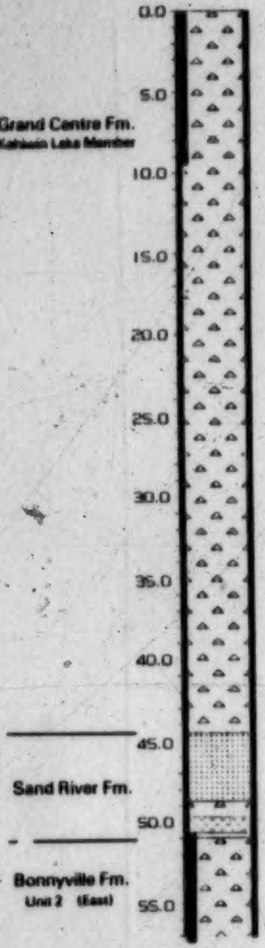


Alberta Geological Survey Testhole 77 SR 10
Location: NE of LSD 1 Sec. 33 Twp. 58 Rng. 9 W of 4 Mer. NTS 73L
Elevation: 2215 FT 675 M Source 1:50,000 NTS 73L/3
Date drilled 197708 02 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1.00								11.0				71.4	22.0	1.2	3.0	1.7	0.7	0.0	591
2.00	29.4	29.6	41.0	31.9	28.5	39.6	1.26	11.3				71.3	20.7	0.8	2.3	3.2	1.5	0.2	526
3.00	31.4	33.1	35.6	33.8	31.9	34.3	1.14	12.5				67.9	25.1	1.4	2.0	2.3	1.1	0.0	546
4.00	31.6	33.4	35.0	33.9	31.6	34.5	1.27					68.0	21.5	0.6	5.7	2.7	1.5	0.0	335
5.00	33.6	33.3	33.1	36.1	32.1	31.8	1.29	11.8				67.4	23.7	0.7	2.5	2.8	2.8	0.0	396
6.00								11.8				69.2	23.7	0.5	2.7	2.4	1.4	0.0	413
7.00	39.6	29.1	31.3	42.3	27.4	30.3	1.63	10.0				67.6	24.4	0.0	3.9	2.7	1.4	0.0	438
8.00								10.3				66.7	24.4	0.6	4.6	1.5	2.2	0.0	324
9.00								9.2				66.3	24.4	1.1	2.6	3.4	2.1	0.0	377
10.00	34.7	38.8	26.5	37.4	37.5	25.1	1.51	10.2				66.9	24.6	1.0	3.2	3.0	1.0	0.2	402
11.00	32.5	39.5	27.9	35.1	38.6	26.3	1.37	9.3				63.2	26.3	0.8	4.5	3.4	1.9	0.0	380
12.00	42.1	36.5	21.3	44.8	35.5	19.7	2.11	7.9				60.1	30.2	0.0	4.1	2.7	2.9	0.0	517
13.00	42.3	36.0	21.7	45.1	34.7	20.2	2.35	4.8				58.5	33.9	0.6	4.1	3.0	1.9	0.0	460
14.00								8.6				61.7	29.6	1.0	3.3	3.3	1.2	0.0	517
15.00	43.2	37.0	19.8	45.8	35.8	18.4	2.36	8.1				61.2	33.9	0.8	0.8	2.9	0.4	0.0	516
16.00								7.6				65.0	26.9	0.0	3.4	3.8	0.9	0.0	557
17.00	41.5	38.8	19.7	44.2	37.3	18.5	2.50	7.9				58.3	34.6	0.2	3.3	2.3	1.1	0.2	566
18.00								8.7				59.7	28.2	0.2	3.3	4.4	4.1	0.0	539
19.00	42.3	38.3	19.4	44.9	37.4	17.7	2.73	8.0				59.9	31.3	0.2	4.1	3.2	1.2	0.0	559
20.00								11.3				63.0	27.0	0.7	3.0	4.6	1.3	0.4	540
21.00	41.3	38.6	20.1	44.0	37.3	18.7	2.29	7.6				56.3	35.2	0.2	3.6	3.8	0.7	0.2	582
22.00								8.3				62.7	27.2	0.6	3.1	5.0	1.3	0.0	515
23.00	41.1	36.0	22.9	43.6	34.8	21.6	2.68	8.2				58.1	32.0	0.7	2.9	5.0	1.2	0.0	556
24.00								10.4				61.0	29.2	0.0	4.2	3.6	1.8	0.2	497
25.00	41.5	38.5	20.0	44.1	37.2	18.7	2.49	8.4				60.9	31.1	0.6	3.9	2.5	0.8	0.2	514
26.00								8.3				65.2	26.6	0.3	3.9	1.4	2.1	0.3	564
27.00	52.1	33.1	14.8	54.9	31.2	13.9	3.63	10.5				68.0	24.1	0.3	2.3	4.0	1.3	0.0	303
28.00								7.4				63.4	27.1	0.0	2.8	2.6	4.0	0.0	494
29.00	47.5	33.0	19.5	50.2	29.0	20.8	3.09	7.9				63.8	30.5	0.9	1.4	2.1	1.2	0.0	564
30.00								6.5				62.8	30.3	0.4	2.2	4.0	0.2	0.0	449
31.00	43.5	35.9	20.6	46.3	34.4	19.4	2.30	8.0				55.8	34.4	0.7	5.7	2.4	0.7	0.2	419
32.00								20.2				69.1	22.7	0.4	3.2	2.6	1.8	0.0	463
33.00	48.6	32.7	18.7	51.2	31.2	17.5	2.34	7.6				62.6	29.5	1.0	2.6	2.8	1.0	0.6	508
34.00	47.9	34.2	17.9	50.5	33.4	16.1	3.08	8.8				68.8	24.1	0.7	2.7	2.7	0.8	0.0	443
35.00	49.2	38.0	12.8	51.9	36.7	11.4	2.58	8.0				66.6	24.9	0.2	3.4	2.8	2.1	0.0	527
36.00	49.2	38.8	12.0	51.8	38.2	10.0	2.77	8.2				63.8	26.6	0.0	3.0	5.6	0.9	0.0	533
37.00	47.1	38.5	14.4	49.8	37.7	12.5	2.37	7.7				66.7	25.9	0.4	1.9	4.3	0.4	0.4	517
38.00								7.8				66.6	25.7	0.5	2.3	3.0	1.9	0.0	428
39.00	38.8	41.3	19.9	41.8	40.3	17.9	1.17	14.8				70.3	24.4	0.7	2.1	2.1	0.4	0.0	434
40.00								9.6				70.1	24.2	0.4	2.8	1.8	0.6	0.0	495
41.00	39.9	39.0	21.1	42.4	38.8	18.8	1.84	8.6				75.1	22.6	0.3	0.0	0.0	2.0	0.0	350
42.00								8.4				65.4	27.6	0.5	2.4	2.7	1.4	0.0	370
43.00	36.2	42.2	21.7	38.6	42.3	19.2	1.85	9.8				70.8	25.5	0.6	0.9	1.2	0.9	0.0	329
44.00								9.8				70.1	24.0	0.0	2.1	1.9	1.5	0.3	582
45.00	35.3	39.4	25.3	37.8	39.4	22.8	1.79	9.0				67.3	28.8	0.6	1.5	1.2	0.3	0.3	330
46.00								8.6				59.1	32.8	0.0	3.2	2.9	1.8	0.0	308
47.00	43.7	31.9	24.4	46.1	31.9	21.9	2.44	8.0				70.9	22.5	0.2	2.2	2.2	0.7	1.2	543
48.00								8.4				60.6	29.1	1.4	3.6	4.1	0.8	0.2	492
49.00	38.8	36.6	24.5	41.2	36.6	22.3	1.81												
50.00								8.7				65.7	29.0	0.5	1.1	1.8	2.0	0.0	389
51.00	40.1	40.4	19.6	42.5	39.8	17.7	1.57	8.0				67.7	26.6	0.3	1.1	2.4	1.8	0.0	372
52.00								8.0				74.6	17.5	1.5	2.0	2.9	0.6	0.6	342
53.00	44.8	34.3	20.9	47.2	33.9	18.9	2.42	7.4				68.7	24.4	1.9	0.9	2.2	1.1	0.6	544
54.00																			
55.00	39.7	33.9	26.4	42.2	33.3	26.4	1.47	8.3				66.4	23.2	2.2	3.1	4.4	0.6	0.0	319
56.00	40.8	33.2	26.0	43.5	32.3	24.2	1.41												
57.00												69.9	20.8	0.9	1.6	2.0	2.4	0.3	336

77 SR 11

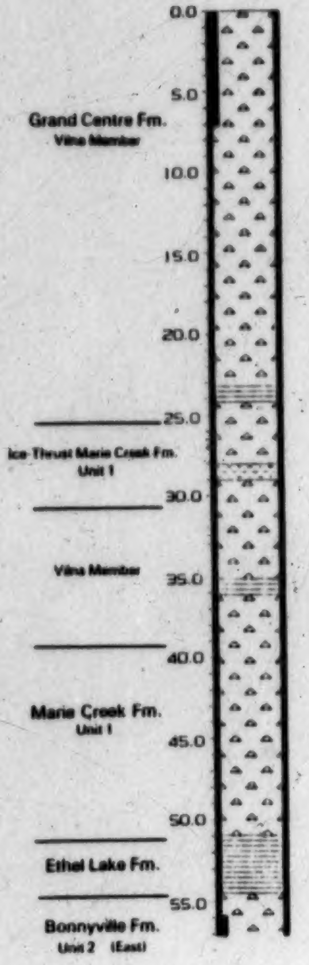
Alberta Geological Survey Testhole 77 SR 11
Location SE of LSD 1 Sec 8 Twp 59 Rng 10 W of 4 Mer , NTS 73L
Elevation 2130 Ft 649 M Source 1 50,000 NTS 73L/3
Date drilled 197708 03 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZI OSS	LST	DST	LOC	OTH	N
3.00	41.2	30.2	28.6	43.7	28.8	27.6	1.93	7.8											
4.00	42.1	30.6	27.2	45.1	29.0	25.9	2.34	8.3											
5.00	45.8	29.2	25.1	48.4	27.7	23.9	2.60	8.3											
6.00	45.7	30.7	23.6	48.4	29.3	22.3	2.70	9.1											
7.00	46.3	29.3	24.4	48.9	28.0	23.1	2.67	10.2											
8.00	43.6	30.9	25.5	46.4	29.2	24.4	2.22	9.3											
9.00	46.5	30.5	23.1	49.1	29.2	21.7	2.78	9.0											
10.00	46.0	30.0	23.9	48.8	30.6	20.6	2.41	9.3											
11.00	45.2	28.7	26.1	47.6	30.1	22.3	2.50	9.1											
12.00	42.8	34.2	23.0	45.3	36.4	18.3	2.18	9.5											
13.00	43.4	34.6	22.0	46.1	36.2	17.7	2.55	8.8				64.5	25.0	0.2	5.5	2.6	1.8	0.4	456
14.00	44.3	30.3	25.5	46.8	32.8	20.3	2.86	9.6				63.4	24.7	0.2	0.4	5.1	3.8	2.5	527
15.00								9.4				69.0	22.7	0.7	3.5	2.4	1.6	0.7	578
16.00	45.1	32.3	22.6	47.7	34.3	18.0	2.39	9.3				68.4	21.9	0.0	3.3	4.3	2.1	0.0	424
17.00								9.3				73.1	18.3	0.3	4.0	2.3	2.0	0.0	301
18.00	44.7	32.5	22.8	47.2	35.0	17.8	2.50	8.6				70.9	22.2	0.0	3.3	2.4	0.7	0.4	450
19.00	42.5	31.4	26.1	45.1	35.1	19.8	2.43	9.0				70.4	22.4	0.4	1.9	3.6	1.3	0.0	477
20.00								10.0				68.0	23.5	0.2	3.6	3.1	1.8	0.0	447
22.00	42.5	31.7	25.8	45.1	34.1	20.8	2.19	9.1				67.5	25.0	0.0	2.8	2.6	2.1	0.0	428
23.00								8.7				68.6	20.2	0.8	3.3	3.9	3.1	0.0	509
24.00	42.5	29.6	27.8	45.2	31.8	23.1	2.82												
25.00																			
26.00	42.2	31.7	26.1	44.8	35.5	19.7	2.37	10.2											
27.00								9.4											
28.00	42.1	32.1	25.8	44.6	35.2	20.2	2.54	12.1											
29.00								11.9											
30.00	42.8	33.5	23.7	45.4	36.9	17.7	2.20												
31.00								8.1											
32.00	44.2	29.9	25.9	46.9	33.1	20.0	2.39	8.0											
33.00								8.3											
34.00	43.3	32.3	24.4	45.7	36.5	17.7	2.47												
36.00	44.9	30.4	24.7	47.5	36.0	16.6	2.64	7.8				66.7	24.6	0.1	3.0	4.0	1.3	0.0	475
37.00								7.8				69.8	22.9	0.4	3.1	2.9	0.8	0.0	450
38.00	44.1	29.1	26.8	46.5	32.6	20.9	2.64	7.8				67.6	26.2	1.4	1.9	2.1	0.6	0.2	485
39.00								7.8				69.1	23.7	0.2	2.2	3.7	1.1	0.0	456
40.00	42.9	32.5	24.6	45.3	35.2	19.5	2.43	8.1				67.6	26.7	0.4	2.3	1.7	1.2	0.0	476
41.00								8.0				62.8	26.0	0.4	4.6	3.1	2.9	0.2	522
42.00	42.6	30.3	27.1	44.9	35.4	19.6	2.55	8.3				64.3	28.8	0.2	2.0	3.8	0.7	0.2	448
44.00	49.3	30.6	20.1	51.7	34.3	13.9	2.85	7.0				69.0	25.2	0.4	2.5	2.3	0.4	0.2	513
49.00								8.4				68.9	20.5	0.3	3.2	4.9	1.7	0.0	347
52.00	47.8	27.4	24.8	50.4	29.6	20.0	2.86	8.5				59.2	37.7	0.5	0.2	1.0	1.4	0.0	414
53.00	46.9	29.4	23.7	49.9	30.2	19.8	2.51	11.5				71.5	24.1	0.5	2.8	0.3	0.7	0.0	576
54.00	43.7	32.5	23.8	46.1	35.2	18.7	2.44	8.2				69.9	25.2	0.4	2.6	0.2	1.3	0.2	452
55.00	45.5	32.6	22.0	48.9	33.5	17.6	2.22	9.2				64.9	30.3	0.6	2.0	1.6	0.6	0.0	505
56.00	47.5	28.8	23.8	50.4	30.8	18.8	2.69	8.9				64.0	31.0	0.9	1.6	0.7	1.7	0.0	442

77 SR 12

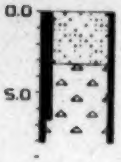
Alberta Geological Survey Testhole 77 SR 12
Location SW of LSD 1 Sec 15 Twp 60 Rng 10 W of 4 Mer , NTS 73L
Elevation 2160 Ft 659 M Source 1:50,000 NTS 73L/3
Date drilled 197708 05 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1.00								12.4				66.3	32.0	0.5	0.2	0.2	1.9	1.2	116
2.00	32.6	20.3	47.2	34.8	25.5	39.7	0.98	13.5				63.0	27.5	0.6	4.9	2.8	1.2	0.0	324
3.00	32.7	23.2	44.2	35.0	26.8	38.2	1.20	14.6				57.6	30.5	1.9	3.7	3.5	2.5	0.2	479
4.00	32.0	23.9	44.1	34.3	27.4	38.3	1.27	13.6				62.6	28.8	2.3	2.1	3.0	0.8	0.2	468
5.00	32.3	24.0	43.7	34.7	28.0	37.4	1.10	14.1				55.4	30.8	0.9	3.2	2.5	0.7	0.0	435
6.00	32.5	20.8	46.7	34.9	25.2	39.9	1.17	12.7				56.1	29.9	1.1	4.0	5.2	2.2	0.0	444
7.00								12.6				56.0	31.3	0.9	3.4	2.5	2.5	0.2	527
8.00	35.5	26.3	38.2	38.2	29.8	31.9	0.98	11.3				56.3	32.5	0.8	2.5	3.2	2.5	0.4	474
9.00								13.5				61.8	30.9	0.9	2.2	2.8	1.2	0.2	576
10.00	35.4	22.9	41.7	38.1	27.0	34.9	1.17	12.4				61.8	30.9	1.5	2.4	1.8	1.4	0.2	544
11.00								11.8				64.7	27.5	1.0	1.9	2.7	2.2	0.0	519
12.00	33.9	27.3	38.8	36.9	32.9	30.2	1.16												
14.00	39.7	27.8	32.5	42.7	31.5	25.8	1.44												
15.00								11.7				55.2	34.1	2.7	3.5	2.4	1.4	0.0	366
16.00	39.2	22.2	38.6	41.9	26.6	31.5	1.04	10.9				53.7	37.8	1.4	2.6	3.3	1.2	0.0	428
17.00								11.2				59.8	31.8	1.1	3.3	3.1	0.9	0.0	453
18.00	34.9	26.0	39.2	37.5	29.9	32.6	1.21	11.4				55.0	34.4	0.4	3.1	5.3	1.9	0.0	544
19.00								10.9				57.6	33.2	1.6	2.3	3.3	1.5	0.3	304
20.00	32.1	25.9	42.0	34.6	30.0	35.3	1.23	11.2				59.9	30.5	0.9	3.0	3.4	1.0	0.0	564
21.00								11.4				59.4	31.1	0.8	2.4	4.5	1.1	0.0	466
22.00	33.4	26.1	40.5	36.0	30.1	33.8	1.16	11.9				54.3	33.1	1.8	5.7	4.4	0.7	0.0	387
23.00								13.2				59.4	31.0	2.1	3.9	3.4	0.0	0.0	335
24.00	32.4	26.7	40.9	34.9	31.0	34.1	1.09	12.5				60.8	29.1	0.9	3.5	4.6	0.9	0.0	546
25.00	33.9	24.2	41.9	36.5	27.9	35.7	1.43	11.3				59.2	32.1	0.3	2.2	4.9	1.0	0.0	588
26.00	35.9	36.3	27.8	38.3	39.6	22.1	2.74	10.5				59.8	29.5	0.0	1.8	7.7	0.8	0.0	558
27.00	34.1	27.3	38.7	36.4	34.7	28.9	2.57	10.1				61.8	30.4	0.0	1.7	5.4	0.6	0.0	516
28.00								9.7				59.6	32.6	0.2	2.2	5.1	0.2	0.0	582
29.00	37.4	28.7	33.8	40.1	33.9	26.0	2.80	9.4				66.5	25.6	0.2	1.8	4.5	1.2	0.0	594
30.00	36.9	27.7	35.4	39.3	33.8	27.0	2.83	10.0				69.0	22.3	0.2	3.0	4.6	0.8	0.0	494
31.00								10.4				66.6	24.8	0.0	1.7	6.3	0.3	0.0	536
32.00								15.3				59.0	29.8	0.0	3.2	6.0	1.9	0.0	315
33.00	26.7	24.5	48.7	28.8	31.8	39.3	0.00	12.4				64.1	26.6	0.0	1.6	6.7	0.6	0.0	312
34.00	25.7	24.5	49.8	27.7	31.9	40.4	1.63	12.5				62.5	26.8	0.0	4.4	6.2	0.0	0.0	339
35.00								9.8				62.0	27.0	0.2	2.8	6.8	0.8	0.2	455
36.00	29.5	25.9	44.6	31.4	33.1	35.5	1.61	11.6				60.3	27.4	0.3	4.6	6.3	0.9	0.3	365
37.00	23.3	24.2	52.5	25.2	31.9	42.9	1.47	12.6				66.9	22.7	0.0	2.7	6.9	0.6	0.3	335
38.00								13.2				61.4	28.3	0.5	2.9	6.0	0.7	0.0	547
39.00	23.5	25.4	51.1	26.0	32.5	41.4	1.83	12.5				56.9	29.0	0.0	3.5	7.6	2.3	0.0	341
40.00								12.0				62.7	26.6	0.0	1.3	8.8	0.6	0.0	308
41.00	35.6	24.7	39.7	37.9	29.9	32.2	2.49	9.9				61.5	25.0	0.0	2.4	10.4	0.6	0.0	488
42.00								10.1				60.8	25.8	0.2	3.1	8.1	1.9	0.0	418
43.00	36.1	27.2	36.6	38.4	32.9	28.7	2.73	9.7				59.4	28.1	0.0	1.4	10.3	0.6	0.0	475
44.00								9.8				64.4	21.0	0.0	2.5	10.7	0.6	0.4	523
45.00	37.1	25.2	37.7	39.4	30.3	30.3	2.60	10.1				66.8	21.9	0.0	3.0	7.6	0.6	0.0	539
46.00								12.5				62.3	25.5	0.9	2.8	7.2	1.2	0.0	321
47.00	21.1	25.6	53.3	23.4	32.9	43.6	1.36	12.7				58.2	29.6	0.3	2.8	8.3	0.7	0.0	567
48.00								12.8				61.2	27.2	0.3	1.3	9.1	0.6	0.0	309
49.00	31.2	23.8	45.0	33.2	30.1	36.7	2.71	11.9				62.7	23.9	0.0	3.6	8.8	0.7	0.0	443
50.00								10.5				56.6	34.8	0.3	1.9	6.4	0.0	0.0	373
51.00								15.7											
52.00								16.8				55.5	38.9	0.0	2.8	2.8	0.0	0.0	36
53.00								16.8											
54.00								16.7											
55.00	45.5	23.9	30.6	48.0	27.4	24.6	2.08	9.5				50.1	42.0	0.0	4.2	2.9	0.6	0.0	447
56.00	54.7	22.5	22.8	57.3	24.8	17.9	2.37	9.2				51.7	42.2	0.0	3.0	1.9	1.0	0.0	524

77 SR 13

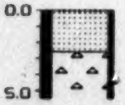
Alberta Geological Survey Testhole: 77 SR 13
Location: SE of LSD 16 Sec 33 Twp 60 Rng 13 W of 4 Mer. NTS: 73L
Elevation: 2125 Ft 648 M Source: 1:50,000 NTS 73L/4
Date drilled: 197708 06 Logged by: M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/MG	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
4.00								10.1				74.2	21.6	0.4	1.0	1.8	1.0	0.0	508
5.00								10.5				66.2	19.8	1.9	4.5	5.5	1.3	0.3	308
6.00								10.4				73.6	21.9	0.5	1.3	1.1	1.6	0.0	379
7.00								10.5				74.9	20.6	0.0	2.0	1.5	1.0	0.0	403
8.00								12.9				59.4	33.0	0.3	1.6	4.1	1.3	0.0	318

77 SR 14

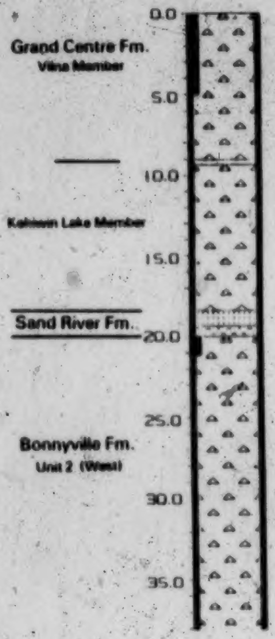
Alberta Geological Survey Testhole: 77 SR 14
Location: SE of LSD 8 Sec 15 Twp 61 Rng 13 W of 4 Mer , NTS: 73L
Elevation: 2075 Ft. 633 M Source: 1:50,000 NTS 73L/5
Date drilled: 197708.06 Logged by: M FENTON



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
3.00								12.7				69.4	26.5	0.7	0.2	0.7	0.5	0.0	599
4.00								11.0				75.6	22.8	0.5	0.5	0.2	0.5	0.0	426
5.00								11.1				73.7	20.6	0.4	0.7	3.6	1.1	0.0	281

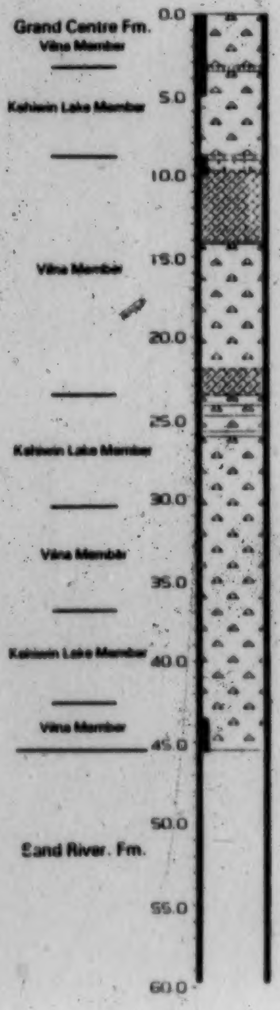
77 SR 15

Alberta Geological Survey Testhole: 77 SR 15
Location: of LSD 9 Sec 15 Twp 61 Rng 13 W of 4 Mer ; NTS 73L
Elevation: 2065 Ft 630 M Source 1:50,000 NTS 73L/5
Date drilled: 197708 06 Logged by M TENION



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	COARSE SAND LITHOLOGY (%) IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								10.3				70.9	23.3	2.0	0.6	2.6	0.8	0.0	347
2.00	43.1	29.5	27.4	45.9	31.4	22.7	1.88	10.9				76.8	19.5	1.5	0.9	1.2	0.0	0.0	323
3.00	40.2	27.3	32.5	43.2	29.4	27.4	1.77	11.1				72.4	21.5	1.1	1.4	1.9	1.6	0.0	363
4.00	38.6	30.6	30.8	41.7	33.2	25.1	1.58	11.2				72.4	22.9	1.0	1.6	1.8	0.4	0.0	511
5.00	34.8	36.9	28.3	38.5	38.1	23.4	1.36	10.3				80.2	18.0	0.6	0.8	0.2	0.0	0.0	349
6.00	38.4	29.5	32.2	41.3	32.9	25.8	1.46	11.0				68.4	24.0	0.0	1.8	2.3	3.5	0.0	396
7.00	39.8	30.6	29.6	42.7	33.7	23.5	1.70	10.5				70.7	24.5	0.5	2.1	1.3	0.8	0.0	379
8.00	38.9	29.6	31.5	41.7	32.9	25.4	1.48	10.9				68.8	26.3	0.8	2.3	1.8	0.2	0.0	388
9.00	40.9	30.3	28.8	43.7	33.5	22.9	1.92	12.0				70.9	23.6	0.9	0.3	3.5	0.3	0.3	313
10.00	50.8	22.2	27.0	53.3	24.3	22.4	2.18	10.2				63.1	28.4	0.9	3.2	1.8	2.3	0.2	436
11.00	51.5	21.4	27.1	54.0	23.5	22.5	1.86	10.1				58.1	36.3	0.3	2.4	1.6	1.3	0.0	375
12.00	44.1	30.1	25.7	46.8	34.5	18.8	2.09	9.6				58.7	30.4	0.9	4.0	3.7	1.9	0.3	322
13.00	41.2	30.6	28.2	44.0	34.9	21.1	1.62	10.8				59.8	33.8	0.8	3.1	1.4	1.1	0.0	358
14.00	40.4	30.9	28.6	43.2	34.9	21.9	1.60	10.7				62.7	27.1	0.6	3.9	3.9	1.6	0.0	306
15.00	44.0	26.1	29.9	46.6	30.0	23.5	1.09	9.2				63.1	30.3	0.2	1.5	3.3	1.3	0.2	396
16.00								9.4				67.6	23.1	0.8	2.2	6.0	0.3	0.0	364
17.00	42.8	30.0	27.2	45.3	34.5	20.2	2.02	9.1				63.6	32.1	1.2	2.1	3.3	0.6	0.0	330
18.00	44.6	28.2	27.2	47.3	32.7	20.0	1.96	9.1				65.5	26.6	0.5	3.8	2.8	0.5	0.2	394
20.00								12.9											
21.00	35.5	31.9	32.6	37.9	37.0	25.1	1.92	10.5				67.5	32.8	0.0	3.7	4.5	1.2	0.2	402
22.00	35.8	32.6	31.6	38.3	38.3	23.3	2.15	9.4				61.0	29.5	0.0	3.4	4.6	0.7	0.7	410
23.00	33.3	32.1	34.6	35.9	38.2	25.8	1.78	10.6				58.2	30.7	0.3	4.8	2.6	3.4	0.0	378
24.00	35.1	30.1	34.8	37.8	35.0	27.1	1.46	9.7				67.7	26.7	0.9	0.9	1.2	2.6	0.0	344
25.00								9.7				61.6	30.1	0.6	2.3	2.0	3.1	0.3	349
26.00	34.8	29.8	35.4	37.6	35.0	27.5	1.36	9.2				55.1	35.6	1.4	2.6	3.2	1.7	0.3	345
27.00								10.0				62.2	27.2	0.3	4.7	3.3	2.2	0.0	360
28.00	34.7	28.0	37.3	37.2	34.3	28.4	1.50	9.1				60.2	33.1	0.3	2.1	2.1	1.9	0.3	372
29.00								8.6				61.2	31.9	0.9	3.5	0.9	1.2	0.3	338
30.00	36.0	33.2	30.8	38.9	38.0	23.2	1.49	9.7				58.4	34.4	0.6	3.8	1.8	0.6	0.3	337
31.00								10.0				55.0	40.9	0.6	0.6	1.6	0.6	0.3	320
32.00	36.3	31.6	32.1	39.1	36.9	24.0	1.30	10.1				64.7	27.3	2.7	1.3	1.0	3.0	0.0	300
33.00								10.5				61.8	31.2	0.7	2.4	0.7	2.4	0.3	288
34.00	36.5	29.5	34.0	39.1	34.3	26.5	1.52	9.6				59.7	29.4	0.3	5.1	2.4	2.7	0.3	333
35.00	37.0	30.8	32.2	39.7	37.6	22.7	1.52	9.8				59.3	34.0	2.0	1.4	1.7	0.9	0.6	344
36.00	37.4	33.4	29.1	40.1	39.2	20.7	1.55	9.6				59.8	33.2	2.0	2.3	1.8	0.5	0.2	391
37.00	37.0	32.2	30.8	39.6	38.1	22.3	1.57	9.4				59.7	33.1	2.6	2.8	1.3	0.2	0.2	390
38.00	37.4	31.2	31.4	40.0	37.7	22.3	1.59	9.3				58.2	35.8	1.4	3.1	1.0	0.6	0.0	514

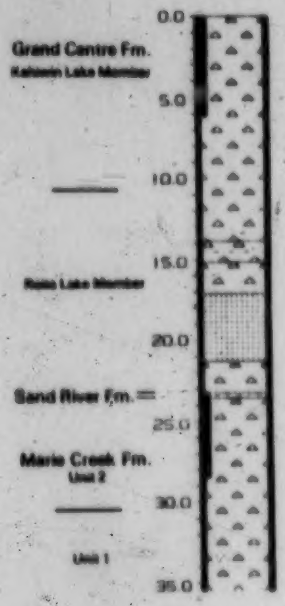
77 SR 16



Alberta Geological Survey Testhole 77 SR 16
Location SE of LSD 9 Sec 18 Twp 61 Rng 9 W of 4 Mer ; NTS 73L
Elevation 2065 Ft ° 630 M Source 1 50,000 NTS 73L/6
Date drilled 197708 07 Logged by ANDRIASHEK

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZI QSS	LST	DST	LOC	OTH	N
1.00	26.9	35.7	37.4	29.2	39.8	31.0	1.16	11.3				61.1	33.1	1.9	1.3	3.2	0.0	0.0	314
2.00	24.8	36.4	38.8	27.0	41.0	32.0	0.88	12.5				62.8	28.7	2.1	2.1	4.2	0.0	0.0	282
3.00																			
4.00	43.0	24.8	32.2	45.1	26.9	27.4	2.19	7.8				62.8	30.5	0.2	2.3	3.1	1.0	0.0	514
5.00	39.9	25.4	34.7	42.4	29.2	28.4	2.05	6.7				69.4	27.3	0.0	1.1	1.8	0.4	0.0	447
6.00	39.5	29.6	31.0	41.9	33.0	25.1	1.95	7.8				67.3	26.5	0.2	1.5	4.3	0.0	0.0	392
7.00	41.6	25.8	32.6	44.3	28.9	26.8	2.42	6.8				64.9	30.0	0.6	1.7	2.3	0.4	0.0	473
8.00	40.9	28.4	30.6	43.4	32.4	24.2	2.16	8.5				67.9	25.9	0.2	1.0	4.2	0.6	0.0	474
10.00								17.7											
11.00								17.4				22.6	6.4	0.0	6.4	0.0	6.4	51.6	31
12.00								17.5				10.5	7.9	0.0	7.9	0.0	2.6	61.0	38
13.00								17.6				0.0	4.0	0.0	18.0	0.0	2.0	76.0	50
14.00								18.1				36.4	22.7	4.5	2.3	0.0	0.0	34.1	44
15.00	28.6	28.7	42.7	30.9	34.2	34.9	1.21	10.3				67.9	24.2	0.7	3.3	3.3	0.3	0.0	302
16.00	31.1	30.8	38.1	33.6	35.4	31.1	1.17	9.8				75.2	26.3	0.9	2.0	2.0	0.2	0.0	448
17.00								14.7				70.1	24.2	0.7	3.4	1.5	0.0	0.0	264
18.00	28.3	30.6	41.0	30.8	34.7	34.5	0.99	11.1				67.6	28.1	1.2	1.2	1.6	0.2	0.0	491
19.00	30.5	31.7	37.9	33.1	36.0	30.9	1.18	11.1				62.9	29.7	0.6	4.7	1.8	0.3	0.0	377
20.00								10.2				62.5	23.3	0.5	2.7	2.8	8.0	0.0	563
21.00	31.1	29.4	39.5	33.6	33.2	33.2	1.32	9.9				64.8	27.2	0.6	3.7	3.3	0.2	0.0	489
22.00	8.3	14.3	77.4	9.2	26.5	64.3	0.35	17.4											
23.00								18.4											
24.00	47.8	23.8	28.4	50.3	26.5	23.2	1.42	9.5											
25.00	35.4	29.5	35.1	37.4	34.8	27.8	1.45	10.5				72.7	24.0	1.3	0.3	1.6	0.0	0.0	370
26.00	46.2	27.2	26.6	48.8	30.3	20.9	2.07	9.0				70.5	24.5	2.6	0.7	1.2	0.4	0.0	417
27.00	40.6	27.4	32.0	43.2	31.3	25.6	1.28	9.8				72.2	19.3	1.8	2.4	3.7	0.6	0.0	327
28.00	40.1	29.5	30.4	42.8	32.7	24.5	1.24	9.3				70.8	22.1	0.6	2.9	3.2	0.3	0.0	308
29.00	39.3	31.5	29.2	42.2	34.5	23.3	1.02	9.7				66.5	28.3	0.7	0.5	2.7	0.2	0.0	562
30.00								8.7				73.8	22.0	1.4	1.1	2.5	0.0	0.0	437
31.00	30.3	34.1	35.6	33.2	38.5	28.3	0.96	8.8				72.6	24.1	0.9	0.9	1.4	0.0	0.0	431
32.00								12.6				78.7	19.3	0.8	0.8	0.4	0.0	0.0	254
33.00	27.1	26.9	46.0	29.1	33.4	37.5	1.08	10.3				71.0	23.4	1.3	0.4	1.5	0.2	0.0	462
34.00								12.0				76.3	19.8	1.6	0.6	1.6	0.0	0.0	308
35.00	26.7	29.7	43.5	28.6	37.6	33.7	1.21	11.8				71.0	24.4	1.8	0.9	1.5	0.0	0.0	324
36.00								11.3				70.9	25.6	1.2	0.2	1.6	0.4	0.0	488
37.00	41.4	25.6	33.0	44.0	29.5	26.5	1.36	0.4				71.5	21.4	2.0	1.8	3.1	0.2	0.0	607
38.00								8.7				76.9	19.3	0.5	1.0	2.0	0.2	0.0	399
39.00	41.1	26.5	32.4	43.6	30.8	25.6	1.62	8.9				70.4	24.4	0.6	0.8	3.7	0.2	0.0	517
40.00	40.0	27.6	32.3	42.7	33.3	24.0	1.15	9.0				70.6	25.1	1.3	0.7	2.2	0.0	0.0	541
41.00	40.3	29.1	30.6	42.7	33.9	23.4	1.38	8.7				71.7	22.7	1.3	1.5	2.6	0.2	0.0	541
42.00	34.7	34.6	30.7	37.7	39.0	23.3	1.17	7.6				68.9	26.3	1.1	0.8	2.0	0.6	0.0	498
43.00	28.3	36.3	35.3	31.1	41.4	27.5	0.86	9.0				73.6	24.3	0.5	0.5	0.7	0.4	0.0	432
43.90	32.7	37.8	29.4	35.0	42.5	22.4	1.20	7.4				59.4	35.1	0.8	1.5	2.0	1.2	0.0	603
44.00	35.4	38.1	26.5	37.6	42.7	19.7	1.17	11.8				65.8	25.4	2.2	2.2	2.8	1.5	0.0	323

77 SR 17

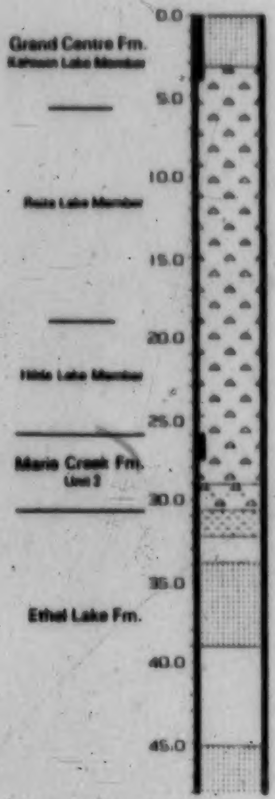


Alberta Geological Survey Testhole, 77 SR 17
Location NE of LSD 15 Sec 9 Twp 61 Rng 8 W of 4 Mer, NTS 73L
Elevation 1900 Ft 579 M Source 1:50,000 NTS 73L/6
Date drilled 197708 08 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN MLTN	QTZ	QTZT OSS	LST	DST	LOC	OTH	N
1.00								7.6				69.8	22.2	6.6	0.0	0.5	0.8	0.0	364
2.00	44.0	26.2	29.8	46.5	29.2	24.3	1.05	12.7				53.7	27.2	5.7	6.3	6.1	0.8	0.0	521
3.00	45.5	26.0	28.6	48.1	27.5	24.4	1.08	11.5				55.0	24.8	5.0	7.0	6.8	1.4	0.0	560
4.00	46.2	25.5	28.2	49.0	26.8	24.2	1.30	11.0				57.0	25.0	4.5	5.9	5.7	1.7	0.0	420
5.00	45.7	25.5	28.9	48.5	26.7	24.8	1.18	10.1				57.7	26.3	5.1	5.3	4.1	1.4	0.0	414
6.00	40.0	26.5	33.5	42.7	28.6	28.7	1.07	9.7				55.5	26.5	3.4	4.0	3.4	1.5	5.5	476
7.00	37.3	26.5	36.2	39.9	29.1	31.0	1.27	9.6				64.8	25.2	2.3	3.6	1.0	2.5	0.5	392
8.00	37.9	26.2	35.9	40.4	29.0	30.6	2.25	10.4				55.2	21.0	2.4	2.1	4.5	0.9	10.8	333
9.00	41.6	26.9	31.5	44.4	29.2	26.4	1.80	8.4				46.2	20.5	1.6	2.4	5.3	1.6	0.0	148
10.00	40.9	26.7	32.4	43.6	28.6	27.8	1.65	8.7				56.0	22.0	1.6	0.4	2.5	0.9	16.5	441
11.00								11.3				76.1	16.8	2.2	0.9	2.2	1.3	0.4	226
12.00	37.4	22.5	40.1	40.0	26.8	33.3	1.47	11.5				66.8	24.0	1.1	2.5	3.0	1.1	1.3	525
13.00								11.6				70.4	21.5	1.6	1.9	2.8	1.4	0.3	362
14.00	32.5	33.9	33.6	35.3	37.8	26.9	1.75	8.4				61.8	19.3	0.7	1.7	16.0	0.5	0.0	411
15.00								8.2				67.1	24.5	2.0	1.6	4.1	0.4	0.0	441
16.00	31.5	28.9	39.5	34.0	33.9	32.2	1.39	8.6				65.2	24.2	2.0	2.8	5.4	0.3	0.0	381
22.00	38.8	24.7	36.5	42.0	27.0	31.0	1.65	9.0				62.6	25.7	1.3	4.2	5.8	0.3	0.0	377
23.00	35.2	27.4	37.4	38.0	29.8	32.2	0.87	8.5				72.8	25.3	0.4	0.4	0.8	0.2	0.0	470
24.00								18.5											
25.00								10.3				57.3	14.8	0.3	4.4	20.9	2.3	0.0	344
26.00	33.2	24.1	42.8	35.6	29.1	35.3	2.32	9.5				64.8	18.5	0.6	1.8	12.4	1.8	0.0	498
27.00	36.2	26.8	37.0	39.3	29.9	30.8	2.56	8.9				64.8	18.0	0.8	3.5	11.1	0.8	1.0	515
28.00	37.1	30.1	32.8	40.3	32.2	27.5	2.94	8.3				58.9	18.9	0.6	4.1	16.7	0.7	0.0	538
29.00	38.6	30.3	31.1	41.5	32.9	25.6	2.40	7.7				60.0	15.5	0.4	2.7	18.6	1.3	1.3	515
30.00	39.5	31.8	28.7	42.4	34.5	23.0	2.38	7.7				47.0	23.8	0.3	2.4	12.0	1.8	12.6	332
31.00	35.7	22.0	42.3	38.1	27.3	34.6	1.75	8.6				60.3	28.5	0.2	3.1	4.3	1.1	2.6	453
32.00	34.9	20.8	44.3	37.3	26.6	36.1	1.76	8.9				61.2	25.9	0.2	2.8	7.7	1.9	0.2	428

77 SR 10

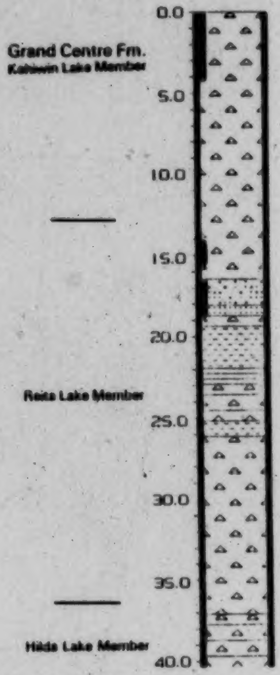
Alberta Geological Survey Testhole, 77 SR 10
Location: NE of LSD 9 Sec 2 Twp 63 Rng 9 W of 4 Mer . NTS 73L
Elevation: 1940 Ft 591 M Source 1:50,000 NTS 73L/6
Date Drilled 19770809 Logged By R JOHNSON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	ICN METH	COARSE SAND LITHOLOGY (%) QTZ	QTZT USS	CLST	DST	LOC	OTH	N
3.00	41.9	27.0	31.1	44.9	29.9	25.3	1.65	10.6				61.4	34.1	0.2	2.2	1.2	0.7	0.0	404
4.00	41.3	27.6	31.1	44.6	30.4	25.0	2.04	9.2				64.6	26.7	0.8	2.6	3.3	1.7	0.0	427
5.00	37.9	24.8	37.4	41.0	28.4	30.5	1.48	9.2				63.9	29.9	0.2	1.5	3.6	0.4	0.2	468
6.00	30.6	23.0	46.4	33.2	28.0	38.8	1.12	12.1				65.0	26.6	0.9	2.8	3.1	1.2	0.3	320
7.00	26.5	24.6	48.9	29.1	29.6	41.3	1.00	13.1				63.8	26.9	1.2	3.1	2.6	1.4	0.7	423
8.00	24.4	24.6	50.9	26.4	31.2	42.4	1.11	14.0				61.0	27.4	0.5	2.4	3.1	1.2	1.4	423
9.00								8.8				65.0	30.2	1.0	1.5	1.8	0.2	0.0	394
10.00	18.7	24.2	56.1	22.3	30.4	47.3	1.31	12.0				65.9	26.7	1.1	1.2	3.4	1.0	0.4	505
11.00								9.8				62.3	27.3	0.3	3.0	5.8	1.2	0.0	329
12.00	33.3	22.0	44.7	35.8	25.8	38.4	1.93	11.6				65.6	27.7	0.5	1.5	3.9	0.5	0.0	584
13.00								11.7				64.9	29.9	0.3	1.3	1.9	1.6	0.0	308
14.00	38.7	22.2	39.1	41.5	26.9	31.6	1.18	10.1				66.5	27.2	1.9	1.6	1.9	0.5	0.3	367
15.00								10.9				69.8	24.2	1.4	0.0	3.9	0.3	0.0	359
16.00	31.9	27.2	40.9	34.5	32.0	33.4	1.11	11.5				63.4	30.2	1.1	0.5	4.2	0.3	0.3	398
17.00								10.6				65.6	27.4	1.5	1.1	4.2	0.2	0.0	456
18.00	39.1	23.0	37.8	41.8	27.1	31.1	2.17	11.0				68.2	26.3	0.7	1.7	2.5	0.2	0.2	399
19.00								11.9				73.4	22.9	0.7	0.7	2.3	0.0	0.0	301
20.00	30.7	28.1	41.2	33.3	33.4	33.3	1.10	12.4				60.7	29.4	1.1	1.9	3.7	2.9	0.3	623
21.00								12.9				57.3	29.6	1.7	3.4	3.9	2.8	0.2	408
22.00	31.2	23.7	45.1	33.7	30.1	36.1	1.04	12.3				61.8	28.5	1.7	3.6	3.4	0.8	0.2	466
23.00								12.6				61.4	26.9	2.1	2.4	4.8	2.1	0.0	371
24.00	31.1	22.4	46.5	33.3	30.1	36.6	0.96	12.9				54.8	34.9	1.3	2.2	5.4	0.6	0.0	458
25.00	29.0	20.8	50.2	31.0	28.2	40.8	0.90	12.6				57.2	29.7	2.3	4.0	5.3	1.2	0.2	387
26.00	35.5	25.0	39.5	38.1	28.6	33.3	2.08	8.6				54.7	22.6	0.0	3.5	18.0	1.1	0.0	561
27.50	44.3	22.3	33.4	46.6	26.3	27.1	2.10	9.7				58.3	22.7	1.0	3.2	13.4	1.0	0.0	379
28.00	41.1	31.2	27.7	44.1	35.4	20.5	1.89	9.5				56.6	26.7	0.3	2.1	11.0	1.1	0.0	380
30.00	36.7	38.4	24.9	39.6	42.1	18.3	1.99	9.8				59.0	24.3	0.0	1.9	11.8	0.2	0.3	415
31.00								17.0											
32.00								17.8											

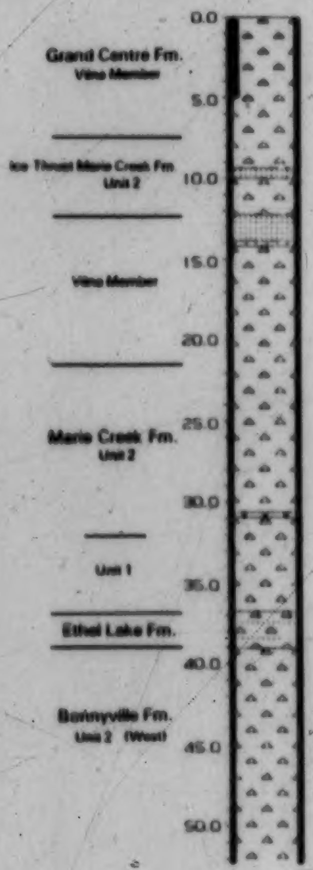
77 SR 19

Alberta Geological Survey Testhole - 77 SR 19
Location SE of LSD 9 Sec 13 Twp 64 Rng 9 W of 4 Mer , NTS 73L
Elevation 1925 Ft 587 M Source 1 50,000 NTS 73L/11
Date drilled 197708 14 Logged by ANDRIASHEK



DEPTH (M)	TEXTURE (%) SAND >62.5um	TEXTURE (%) SILT	TEXTURE (%) CLAY <4um	TEXTURE (%) SAND >50um	TEXTURE (%) SILT	TEXTURE (%) CLAY <2um	TEXTURE (%) VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	MATRIX CARBONATE CO3 (%)	MATRIX CARBONATE CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								9.1				66.5	32.1	0.2	0.0	0.4	0.6	0.0	454
2.00	46.7	19.5	33.8	49.5	22.3	28.2	2.60	8.8				66.8	27.3	1.1	0.9	1.6	0.3	0.0	565
3.00	43.3	24.4	32.3	46.8	26.0	27.2	1.50	8.0				61.1	30.8	0.4	3.9	2.8	1.0	0.0	532
4.00	43.5	20.4	36.1	46.2	26.4	27.4	2.39	7.0				61.5	30.9	0.2	3.0	3.9	0.5	0.0	592
5.00	43.6	19.4	37.0	46.3	21.2	29.5	2.70	6.7				61.9	29.8	0.3	2.0	2.8	2.6	0.6	352
6.00	44.1	21.0	35.0	46.8	25.0	28.3	2.47	9.5				65.9	25.9	0.0	2.9	4.9	0.3	0.0	305
7.00	43.5	21.9	34.6	46.3	27.4	26.3	2.19	6.4				63.5	28.6	0.3	2.7	4.5	0.3	0.0	559
8.00								7.1				68.1	24.1	0.3	2.5	3.7	1.0	0.2	566
9.00	44.3	20.8	34.9	46.9	27.2	25.9	2.13	7.3				66.8	24.0	0.6	1.9	5.7	0.9	0.0	317
10.00								6.7				66.3	27.1	0.4	2.8	3.0	0.4	0.0	528
11.00	47.4	20.9	31.7	50.2	25.2	24.5	2.69	6.4				68.0	25.9	0.4	2.2	3.2	0.4	0.0	506
12.00								6.9				67.8	27.1	0.8	1.3	2.8	0.2	0.0	388
13.00								7.8				67.9	24.2	0.6	2.7	4.1	0.4	0.0	508
14.00	38.5	18.7	42.8	41.0	23.5	35.5	2.25	8.4				66.1	28.0	0.6	1.3	3.0	0.6	0.3	304
15.00	38.8	24.4	36.8	41.6	27.1	31.3	1.68	7.6				53.0	43.1	2.4	0.3	0.0	1.2	0.0	332
19.00	47.2	20.9	31.9	49.9	24.7	25.3	3.35												
20.00								14.5											
21.00								11.9											
22.00								13.6				51.0	26.5	0.0	11.2	4.1	6.1	1.0	98
23.00	33.0	18.8	48.2	35.6	22.7	41.7	1.44	10.0				68.2	28.8	0.3	0.9	1.8	0.0	0.0	333
24.00	26.3	25.8	47.9	29.0	31.0	40.0	1.33	9.5				57.6	35.7	0.9	0.9	3.8	0.9	0.0	314
25.00								10.5											
26.00	37.3	19.4	43.3	40.0	24.4	35.6	1.91	10.3				68.7	27.6	0.6	0.6	1.7	0.9	0.0	355
27.00	36.7	18.7	44.6	39.2	24.0	36.7	1.66	8.0				72.4	24.7	0.4	0.7	1.8	0.0	0.0	450
28.00	38.4	18.5	43.0	41.3	23.6	35.2	2.03	8.2				72.6	23.7	0.7	1.1	0.9	0.9	0.0	436
30.00								7.9				67.9	28.4	1.2	0.4	1.6	0.4	0.0	406
31.00	33.8	24.3	41.9	36.5	28.8	34.7	1.42	9.0				68.6	27.6	1.3	1.6	0.9	0.0	0.0	315
32.00								8.8				68.7	27.6	0.3	1.2	1.5	0.3	0.0	326
33.00	31.1	20.4	48.4	33.5	26.6	39.9	1.64	9.4				66.8	29.3	0.3	1.4	1.9	0.3	0.0	362
34.00								7.7				72.6	24.5	0.8	0.8	0.8	0.4	0.0	391
35.00	35.6	21.9	42.5	38.1	26.7	35.2	1.61	8.9				70.7	26.1	0.3	1.1	1.4	0.3	0.0	392
36.00								7.6				69.8	25.1	2.3	1.8	0.5	0.4	0.0	434
37.00	17.7	23.6	58.7	19.5	29.9	50.7	0.64	11.3				68.5	25.3	1.4	1.7	3.1	0.0	0.0	292
38.00	19.4	23.6	56.9	21.3	29.1	49.6	1.04	10.9				66.9	29.9	1.0	0.5	1.4	0.2	0.0	578
39.00	26.5	19.9	53.6	28.4	25.2	46.4	1.14	7.9				65.1	29.3	2.5	0.6	2.5	0.0	0.0	371
40.00	36.8	21.9	41.3	38.9	26.6	34.5	1.52	7.2				70.8	26.9	0.3	1.2	0.6	0.3	0.0	342

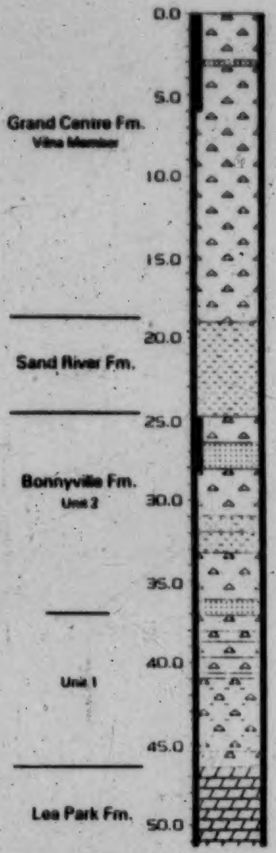
77 SR 20



Alberta Geological Survey testhole 77 SR 20
Location of LSD 1 Sec 25 Twp 63 Rng 11 W of 4 Mer , NTS 73L
Elevation 1955 ft , 596 m Source 1:50 000 NTS 73L/5
Date drilled 197708 16 Logged by L. FULZAK

	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN MET	QTZ	QTZT USS	LST	DST	SHL	OTH	N
1.00								22.5				59.7	32.6	2.2	1.1	3.9	0.5	0.0	181
2.00	22.8	32.9	44.3	24.8	37.3	37.8	0.80	23.8				58.5	31.2	1.3	2.1	4.3	2.6	0.0	234
3.00	27.9	30.8	41.3	30.8	34.1	35.0	0.78	22.0				56.1	37.4	1.1	0.8	2.0	0.8	0.0	254
4.00	30.5	26.9	42.6	33.1	29.9	37.0	0.94	21.8				52.4	29.7	2.0	1.4	1.7	1.7	11.2	357
5.00	28.9	29.7	41.3	31.5	33.0	35.4	0.86	21.7				50.1	28.2	2.7	3.0	3.6	2.7	9.8	337
6.00	30.2	27.8	42.0	32.8	30.9	36.3	0.80	24.0				56.8	31.1	1.9	6.0	2.8	0.6	0.6	315
7.00								22.4				54.3	32.9	2.8	3.7	5.6	0.3	0.3	322
8.00	35.0	29.2	35.8	37.7	32.1	30.2	1.15	10.3				51.8	36.2	2.6	5.8	3.2	0.3	0.0	309
9.00								8.7				54.2	26.8	2.6	7.2	6.5	2.6	0.0	153
10.00	62.7	20.0	17.3	64.9	22.0	13.1	2.04	3.3				65.5	25.3	4.6	2.9	1.2	0.2	0.2	478
11.00	57.4	25.5	17.1	59.9	28.4	11.7	1.53	17.3				45.9	30.7	7.0	8.5	6.3	9.9	0.6	316
12.00	47.1	24.9	28.0	50.0	27.1	22.9	1.11	8.7				54.6	30.7	4.2	3.3	6.3	0.8	0.0	338
14.00								2.2											
15.00	34.6	30.3	35.1	36.5	34.8	28.3	1.05	9.5				70.3	24.7	1.4	1.1	2.0	0.4	0.0	441
16.00	32.6	32.1	35.2	35.2	35.9	28.9	0.96	8.3				63.8	29.9	1.9	3.3	1.6	0.3	0.3	368
17.00	31.5	34.8	33.7	34.1	38.2	27.7	1.15	9.5				62.9	29.0	0.9	2.2	4.3	0.7	0.0	445
18.00								8.8				60.7	30.7	1.0	3.3	3.7	0.7	0.0	300
19.00	30.8	32.5	36.7	33.2	36.9	29.9	1.19	8.9				66.1	25.3	1.5	1.8	3.5	1.5	0.2	451
20.00								9.2				60.4	31.5	1.6	1.6	3.7	1.7	0.0	489
21.00	29.1	30.2	40.7	31.2	35.1	33.7	1.39	10.1				61.9	26.7	1.4	1.8	3.9	1.2	0.0	431
22.00								9.4				53.5	34.2	2.0	4.1	3.6	1.6	0.9	439
23.00	34.4	33.1	32.5	37.1	36.2	26.7	1.09	8.8				49.5	33.6	3.2	5.7	5.9	1.4	0.7	440
24.00								9.1				53.5	32.0	2.6	6.8	3.8	1.2	0.2	422
25.00	38.3	30.3	31.4	40.6	33.2	26.2	1.53	9.9				52.2	34.8	2.3	2.7	6.7	1.3	0.0	299
26.00								10.4				50.3	33.4	4.3	6.5	3.2	2.3	0.6	352
27.00	20.7	32.1	47.2	22.6	37.3	40.0	0.72	11.9				60.8	31.3	2.5	1.1	3.1	1.4	0.0	355
28.00								12.1				53.8	28.9	4.4	3.3	6.6	2.9	0.0	273
29.00	33.1	29.7	37.2	35.2	35.3	29.5	1.20	10.8				49.5	35.3	1.8	6.7	5.1	1.5	0.0	386
30.00	34.0	31.4	34.6	36.4	35.9	27.8	0.92	10.2				47.4	34.1	4.3	5.9	4.9	2.9	0.4	487
31.00	34.3	28.4	37.3	36.6	33.9	29.6	1.03	10.6				46.3	36.1	4.2	6.2	4.4	2.0	0.7	404
32.00	28.8	30.3	40.9	30.9	35.3	33.8	0.90	11.0				53.1	32.3	2.7	6.5	3.0	1.7	0.5	399
33.00								12.9				64.0	25.9	3.3	1.2	4.0	1.5	0.0	397
34.00	21.8	29.1	49.0	23.6	35.6	40.8	0.64	12.1				61.8	28.3	2.5	2.8	3.3	1.0	0.2	395
35.00								12.2				57.6	30.4	2.7	2.7	4.5	1.8	0.2	444
36.00	23.2	31.5	45.3	25.0	38.5	36.5	0.86	11.7				52.7	33.8	4.4	3.6	3.6	1.3	0.5	385
37.00								8.4				59.2	36.5	0.0	1.8	2.5	0.0	0.0	277
38.00	23.4	38.4	38.2	26.1	42.7	31.2	0.80	10.5				62.0	30.9	1.2	2.1	3.6	0.0	0.2	418
39.00								9.1				56.2	37.7	0.6	2.8	3.2	0.3	0.0	316
41.00	41.5	33.5	25.0	44.2	24.9	30.9	1.61	6.1				43.9	49.5	0.9	3.9	1.2	0.6	0.0	335
42.00	39.3	23.4	37.3	40.6	27.9	31.6	6.79	9.7				50.3	42.9	2.9	1.3	1.3	0.6	0.6	310
43.00	37.7	30.3	32.0	40.5	34.1	25.4	1.11	9.1				49.8	42.0	3.3	0.0	1.5	3.0	0.4	269
44.00								9.1				46.6	45.8	3.1	1.3	1.8	1.3	0.0	386
45.00	35.2	32.1	32.7	38.0	36.2	25.8	1.33	8.8				44.5	48.1	3.7	0.9	0.9	1.3	0.0	458
46.00	36.6	30.8	32.6	39.5	34.9	25.7	1.26	11.2				50.3	44.5	2.4	0.9	0.8	0.9	0.9	326
47.00	36.7	31.6	31.8	39.3	34.9	25.8	1.09	10.1				48.8	41.3	3.9	1.3	1.0	1.6	0.0	305
48.00	24.1	31.9	44.0	25.9	39.6	34.1	0.98	11.6				64.4	29.2	2.8	1.4	0.7	1.1	0.3	281
49.00	33.3	28.3	38.3	36.2	31.6	32.3	0.84	10.8				49.4	42.3	1.9	1.5	2.6	1.9	0.4	265
50.00	32.7	28.0	39.3	35.4	31.4	33.2	0.96	9.9				46.2	45.5	1.3	2.9	1.3	2.0	0.7	348
51.00	35.3	29.3	35.5	38.0	32.0	30.0	1.07	9.6				50.7	39.7	2.6	5.2	0.2	1.4	0.7	436
52.00	36.7	29.1	34.2	38.3	32.2	28.5	1.16	9.5				48.9	46.4	2.8	1.1	0.1	0.0	0.3	280

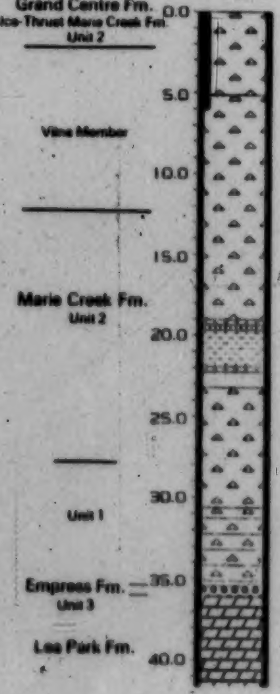
77 SR 21



Alberta Geological Survey Institute 77 SR 21
Location N of LSD 10 Sec 18 Twp 63 Rng 12 W of 4 Mer NTS 73L
Elevation 1990 Ft 607 M Source 1:50,000 NTS 73L/9
Date drilled 197708 17 Logged by ANDRIASHEK

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/MG	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								15.1				56.7	38.9	1.7	0.6	0.4	1.5	0.0	455
2.00	36.2	26.4	37.4	38.8	29.1	32.1	1.37	12.8				60.3	29.6	1.3	4.3	3.7	0.8	0.0	375
3.00	32.9	29.2	37.9	35.4	31.5	33.1	1.11	13.7				67.0	24.8	1.5	3.8	1.5	1.3	0.0	524
4.00	30.1	30.4	39.5	32.5	33.7	33.8	1.15	15.5				63.5	26.8	2.1	4.8	2.1	0.7	0.0	291
5.00	34.7	26.3	39.0	37.3	28.7	34.0	1.31	13.7				64.3	26.2	1.4	3.3	3.8	1.8	0.0	614
6.00	34.6	30.5	34.9	37.3	33.4	29.3	1.22	15.3				58.1	31.5	1.6	2.9	3.7	2.2	0.0	375
7.00	26.9	30.0	43.1	29.2	35.5	35.3	0.96	15.7				60.9	27.9	1.4	3.6	4.5	1.7	0.0	358
8.00								16.7				65.9	24.6	0.7	2.7	3.7	2.1	0.0	402
9.00	35.2	30.9	33.8	37.8	34.4	27.8	1.36	14.5				56.0	31.2	2.7	4.0	2.5	3.5	0.0	593
10.00								15.2				62.2	27.3	1.9	4.6	2.2	1.6	0.3	370
11.00	32.7	30.2	37.1	35.2	34.8	29.9	1.10	14.7				60.8	30.3	1.9	2.7	1.5	1.9	0.5	373
12.00								15.6				62.6	27.7	1.2	2.6	3.3	2.4	0.0	490
13.00	31.7	30.5	37.8	34.0	34.4	31.6	1.06	15.9				65.6	23.4	2.9	2.7	3.4	1.3	0.6	445
14.00								15.0				63.7	30.3	1.0	1.6	2.3	0.8	0.2	485
15.00	35.4	28.3	36.3	37.9	31.1	31.1	1.00	15.3				61.7	30.4	1.3	1.3	2.0	3.0	0.2	394
16.00								15.0				66.0	25.6	0.8	1.3	3.3	2.8	0.2	391
17.00	38.2	27.6	34.2	41.0	30.9	28.0	1.73	13.1				53.1	40.1	1.4	2.5	2.0	0.6	0.3	354
18.00								15.5				56.1	30.5	0.3	4.2	5.0	2.1	1.9	383
19.00	31.5	33.9	34.6	35.1	36.2	28.8	0.90	12.1				56.0	30.8	0.0	5.6	2.6	5.0	0.0	302
20.00								17.5											
21.00								19.6											
22.00								18.5											
25.00	38.5	30.9	29.7	42.6	32.9	24.5	1.53	12.0				56.1	36.8	0.7	2.1	1.4	1.2	1.4	423
26.00	39.1	31.4	29.5	42.3	33.0	24.7	1.28												
28.00	33.6	31.9	34.4	36.5	34.4	29.0	1.41	10.9				66.8	26.6	0.8	3.4	2.0	0.0	0.3	353
29.00	33.1	33.0	33.9	36.0	35.0	29.1	1.25	12.6				66.7	26.1	0.3	3.6	2.0	0.7	0.7	303
30.00	32.1	36.2	31.7	34.7	38.6	26.7	1.77	10.8				63.9	29.2	0.4	3.3	1.9	1.2	0.0	480
31.00								13.2				62.6	29.9	0.9	3.4	1.5	1.2	0.3	324
32.00								12.3				68.1	24.7	0.8	3.4	1.5	0.8	0.8	263
33.00								17.5				59.4	23.2	0.0	2.9	5.8	8.7	0.0	69
34.00	34.9	28.8	36.3	37.5	32.9	29.5	1.19	11.8				64.4	26.0	0.2	4.9	2.6	1.9	0.0	531
35.00	30.0	33.7	36.4	32.6	37.3	30.1	1.47	13.4				60.3	28.9	0.9	4.3	3.2	2.2	0.2	443
36.00	34.0	33.4	32.6	36.7	36.8	26.5	1.03												
37.00	33.2	31.7	35.1	35.8	35.6	28.6	1.22	12.6				56.6	29.1	1.3	5.2	1.2	2.7	0.8	519
38.00	26.5	35.0	38.5	28.7	40.3	31.0	1.06												
39.00								14.3				59.5	32.2	0.2	5.1	1.8	1.0	0.2	494
40.00	20.1	30.4	49.5	21.6	38.2	40.2	1.04	13.5				63.6	29.5	0.7	3.7	1.2	1.4	0.0	431
41.00	18.3	31.5	50.2	47.9	10.9	41.2	0.00	13.3				71.6	22.5	0.8	2.3	2.5	0.3	0.0	356
42.00	21.8	33.4	44.8	23.3	42.1	34.7	1.08	13.2				64.3	30.1	0.0	3.4	1.3	0.9	0.0	535
43.00	20.6	31.1	48.3	22.2	39.4	38.4	1.16	13.0				65.8	26.2	0.1	5.0	1.7	1.0	0.0	301
44.00	18.5	33.1	48.5	19.8	40.7	39.4	0.98	13.4				64.9	25.8	0.8	2.4	2.7	3.3	0.0	488
45.00								13.8				66.4	26.2	1.3	1.7	3.5	0.9	0.0	461
46.00	41.0	34.9	24.1	43.5	38.2	18.4	2.06	10.6				58.8	32.9	0.0	4.0	2.8	1.1	0.3	352
47.00								14.6											
48.00								15.2											
49.00								15.4											
50.00								15.4											

77 SR 22

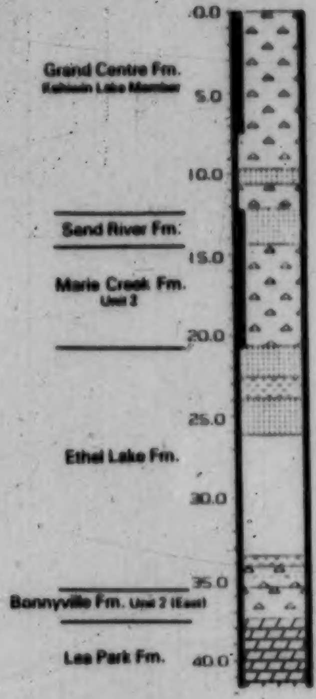


Alberta Geological Survey Testhole 77 SR 22
Location 5 of LSD 3 Sec 31 Twp 64 Rng 13 W of 4 Mer . NTS 73L
Elevation 1920 Ft 585 M Source 1 50,000 NTS 73L/12
Date drilled 197708 20 Logged by C LUTZAK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METH	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								13.5				42.2	26.9	5.7	9.3	14.8	1.1	0.0	547
2.00	42.6	31.4	27.0	44.4	33.8	21.8	1.62	14.5				44.4	23.4	6.8	11.2	13.6	0.5	0.0	206
3.00	36.8	31.5	31.7	39.6	33.8	26.6	1.51	13.7				62.4	26.1	3.4	3.0	4.0	1.0	0.0	594
4.00	33.2	33.5	33.4	35.7	36.4	27.8	1.25	13.9				61.2	29.5	3.2	2.9	1.3	1.9	0.0	312
5.00	33.5	31.8	34.7	36.3	34.6	29.1	1.08	12.6				63.2	26.9	2.2	2.7	3.6	1.3	0.0	446
6.00	34.8	30.8	34.4	37.4	34.5	28.2	1.59	12.6				63.8	24.4	1.9	2.6	5.2	1.9	0.0	307
7.00	31.6	34.1	34.3	34.2	38.0	27.8	1.13	12.5				65.4	24.4	1.1	2.4	4.1	2.2	0.4	541
8.00	32.8	32.6	34.6	35.6	35.4	29.1	1.08	11.2				62.1	28.9	1.7	1.7	3.4	1.9	0.0	464
9.00								12.2				67.6	21.1	2.9	1.1	5.5	1.5	0.2	451
10.00	33.4	32.8	33.9	36.1	36.7	27.1	1.27	11.6				67.8	23.1	1.8	2.4	2.8	1.6	0.4	494
11.00								13.9				68.5	24.6	0.2	1.2	2.5	2.4	0.0	419
12.00	28.4	33.5	38.1	30.8	38.6	30.6	0.90	14.4				68.6	24.2	0.0	3.3	2.6	1.0	0.2	389
13.00								13.9				61.0	25.2	1.6	6.6	4.2	1.1	0.3	377
14.00	34.5	30.7	34.7	37.4	35.2	27.4	0.92	13.5				61.9	22.7	1.7	7.0	4.7	2.0	0.0	299
17.00	34.8	31.0	34.3	37.5	34.4	28.1	1.12												
18.00	37.7	37.0	25.3	40.6	34.2	25.3	1.11	11.2				59.7	21.3	3.2	6.7	6.0	2.5	0.6	315
23.00	37.2	30.8	32.0	40.2	34.4	25.5	1.14	12.5											
24.00	37.3	31.4	31.3	40.1	35.5	24.4	1.10	10.9				59.5	24.0	2.0	4.9	6.9	2.2	0.4	491
25.00	30.3	31.3	38.5	32.7	35.1	32.2	0.90	11.9				58.3	27.5	2.9	5.9	4.4	0.8	0.2	477
26.00	31.8	30.3	37.9	34.1	35.4	30.5	0.91	11.8				54.0	30.7	0.5	5.7	4.6	3.9	0.5	387
27.00								12.1				57.5	29.5	1.2	4.2	6.0	1.5	0.0	400
28.00	30.3	31.8	37.9	32.4	36.8	30.8	1.23	13.7				61.9	27.3	0.3	3.7	2.7	3.7	0.3	373
29.00								13.3				65.9	25.3	1.4	3.0	2.2	1.4	0.8	502
30.00	28.0	29.6	42.4	29.9	35.0	35.1	0.72	12.6				65.0	25.2	2.4	2.4	2.2	1.1	0.7	449
31.00								13.2				69.1	22.5	1.2	3.0	3.0	0.9	0.2	431
32.00	29.9	32.4	37.7	32.0	39.0	29.0	1.15	13.2				65.4	27.2	1.0	3.6	2.3	0.5	0.0	390
33.00	26.3	35.7	38.0	28.1	42.4	29.5	0.82	12.6				59.4	32.8	1.5	4.6	1.5	0.0	0.0	259
34.00	30.0	33.1	36.9	32.4	39.7	28.0	0.90	12.2				66.7	21.6	2.8	4.7	3.6	0.5	0.0	361
35.00	16.8	44.3	39.0	19.0	44.2	36.8	0.64	14.2				61.6	28.0	0.6	4.3	4.3	1.2	0.0	164
37.00								14.9											
39.00								13.9											

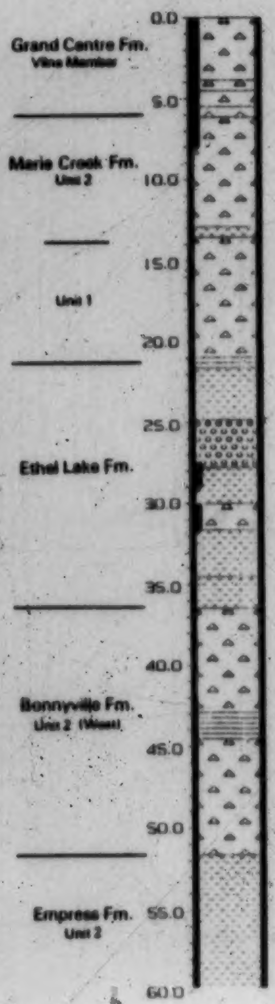
77 SR 23

Alberta Geological Survey testhole 77 SR 23
Location NE of LSD 6 Sec 31 Twp 65 Rng 10 W of 4 Mer NTS 73L
Elevation 2030 FT 619 M Source 1:50,000 NTS 73L/11
Date drilled 197708 21 Logged By C. LUTZAK



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC-SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	46.3	33.9	19.8	49.1	29.1	21.9	2.26												
2.00	43.5	13.4	43.2	45.3	6.5	48.2	0.04	20.0											
3.00	45.9	26.4	27.7	48.4	21.3	30.3	1.88	9.5				68.5	24.7	0.5	2.8	2.1	1.3	0.0	388
4.00	46.5	29.7	23.8	49.1	24.6	26.4	2.63	9.8				63.9	21.2	0.6	3.4	3.8	1.2	5.8	499
5.00	46.3	27.8	25.9	49.0	22.7	28.3	2.49	9.5				61.5	23.5	0.6	4.1	3.4	1.7	5.5	293
6.00	44.0	29.5	26.5	46.5	24.6	28.9	2.40	9.5				66.5	23.5	0.7	4.0	3.6	0.7	0.9	421
7.00	46.4	35.5	18.1	49.0	30.1	20.8	2.24	9.4				65.2	21.3	0.5	4.2	5.8	1.6	1.4	431
8.00	16.5	48.6	34.9	18.6	41.9	39.6	1.04	14.7				55.7	26.1	0.0	3.7	6.2	6.0	2.3	362
9.00	28.2	38.8	33.0	30.9	32.3	36.8	1.02	12.1				58.9	28.9	0.4	5.4	4.8	1.2	0.2	480
10.00																			
11.00	15.8	47.0	37.2	18.1	40.0	41.9	0.94												
12.00	23.1	48.5	28.4	25.3	42.9	31.8	0.55	12.8											
13.00																			
14.00																			
15.00	37.2	43.8	19.0	40.2	38.4	21.4	2.28	9.5				64.2	24.7	0.4	3.2	5.7	1.8	0.0	441
16.00	36.4	38.8	24.8	39.6	41.6	18.8	2.21	12.0				65.5	23.7	0.2	2.9	7.3	0.4	0.0	481
17.00	39.1	33.4	27.5	42.0	36.5	21.5	2.46	7.1				66.5	23.4	0.2	3.2	4.9	1.8	0.0	492
18.00	41.3	30.3	28.4	44.1	33.6	22.3	2.58	9.5				64.4	22.9	0.8	1.9	8.2	1.5	0.2	514
19.00	38.9	31.3	29.8	41.6	34.9	23.5	2.44	10.3				67.7	23.3	0.2	1.8	5.2	1.8	0.0	488
20.00	41.5	31.0	27.5	43.9	34.7	21.4	2.01												
23.00												57.2	27.4	3.8	6.2	3.8	0.9	0.6	339
33.50																			
34.00								9.7				65.9	26.3	0.3	2.3	3.2	1.6	0.3	308
36.00	45.9	28.4	25.6	48.5	32.3	19.2	2.14	8.9				55.2	37.8	0.6	5.4	0.9	0.0	0.0	460
37.00	44.8	29.0	26.1	47.3	32.1	20.6	2.29	8.9				61.5	30.9	0.0	3.8	3.2	0.6	0.0	314
38.00								17.1											
39.00								16.5											
40.00								16.1											
41.00								16.6											

77 SR 24

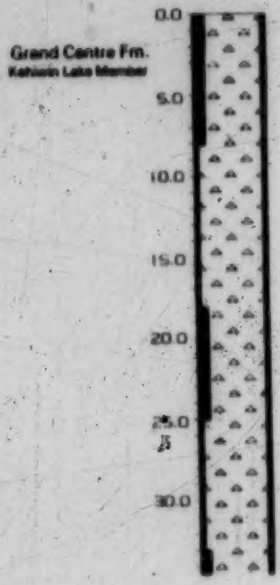


Alberta Geological Survey Testhole 77 SR 24
Location: SE of LSD 8 Sec 19 Twp 65 Rng 12 W of 4 Mer. NTS 73L
Elevation: 1920 Ft. 585 M. Source 1:50,000 NTS 73L/12
Date drilled: 19770822 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/MG	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								9.1				62.2	35.9	0.8	0.0	0.0	1.0	0.0	384
2.00	31.8	35.0	33.2	34.3	34.4	31.3	0.68	13.1				56.1	31.7	2.7	3.5	4.6	1.3	0.0	369
3.00	25.1	39.3	35.6	27.4	38.7	33.9	0.64	14.8				57.0	30.0	1.8	1.5	6.7	3.0	0.0	330
4.00	26.8	36.7	37.5	30.0	34.7	35.3	0.51	14.5				61.8	31.7	2.1	1.3	3.0	0.0	0.0	233
5.00	9.8	39.0	51.2	11.0	40.4	48.6	0.12	17.8				70.8	20.3	3.5	4.4	0.0	0.8	0.0	113
6.00																			
7.00	38.5	36.9	24.6	41.8	35.3	22.9	1.19	9.8				63.9	29.9	1.4	2.4	1.4	1.0	0.0	294
8.00								11.0				57.9	25.7	3.6	6.4	5.7	0.7	0.0	440
9.00	37.2	35.4	27.4	40.2	34.2	25.6	1.64	9.8				67.1	24.1	2.1	2.3	2.7	1.6	0.0	560
10.00								10.4				65.9	27.0	0.2	1.9	4.5	0.5	0.0	425
11.00	40.2	34.6	25.2	42.7	33.9	23.4	2.35	10.3				64.2	29.6	0.0	3.0	3.2	0.0	0.0	402
12.00	38.2	35.8	26.0	40.8	35.1	24.0	1.76	11.5				63.8	29.3	0.4	3.1	3.1	0.2	0.0	450
13.00								10.6				54.4	36.6	0.6	3.7	4.4	0.3	0.0	320
14.00	30.3	37.0	32.7	32.7	36.7	30.6	1.06												
15.00								13.2				59.3	28.6	1.2	2.7	5.4	2.7	0.0	332
16.00	29.7	40.8	29.5	32.3	40.0	27.7	0.96	12.1				59.6	28.8	1.7	5.0	4.5	0.2	0.0	399
17.00								12.5				56.7	28.2	3.0	4.2	5.1	2.4	0.4	504
18.00	28.5	39.8	31.7	31.4	38.9	29.7	0.72	13.8				66.0	25.8	1.5	2.5	2.8	1.2	0.0	324
19.00								11.3				55.5	30.8	1.7	6.2	3.8	1.7	0.2	468
20.00	36.2	36.8	27.0	39.0	35.5	25.5	1.11	11.4				57.3	31.3	3.1	4.1	2.3	1.6	0.2	483
21.00								14.9				78.7	16.2	0.0	2.5	0.0	2.4	0.0	80
22.00								20.8											
23.00								16.3											
24.00								17.6				74.2	16.1	3.2	3.2	3.2	0.0	0.0	31
25.00												56.2	36.2	0.0	5.0	2.5	0.0	0.0	80
26.00																			
27.00																			
27.50								14.7				69.6	25.0	0.0	4.3	1.0	0.0	0.0	92
29.00																			
30.00	19.3	55.7	25.0	21.6	55.5	22.8	0.53												
34.00								15.0											
35.00								19.4											
36.00								18.0											
37.00	36.2	38.6	25.2	39.3	37.5	23.2	1.42	10.7				59.0	38.5	0.6	0.6	0.6	0.3	0.3	322
38.00	22.1	44.8	33.1	24.1	45.5	30.5	0.60	17.3				62.9	22.9	0.6	6.4	5.6	0.4	1.1	467
39.00	40.0	35.1	24.9	42.7	34.1	23.2	1.46	9.7				57.2	38.3	1.4	1.7	1.5	0.4	0.0	514
40.00	41.5	32.8	25.8	44.2	31.6	24.2	2.05	9.5				54.7	36.0	0.7	1.7	6.5	0.2	0.0	400
41.00	40.3	35.1	24.5	42.9	34.1	23.0	2.00	9.6				66.6	27.8	0.0	2.1	0.2	1.2	0.2	485
42.00	34.5	41.8	23.7	37.3	40.7	22.0	1.22	10.8				65.3	29.1	1.8	1.2	0.6	1.5	0.3	326
44.00								17.3				68.6	25.4	2.6	0.2	0.2	2.8	0.2	465
45.00	33.9	39.2	26.9	36.2	39.1	24.7	0.98					49.2	41.9	3.2	0.0	9.7	0.0	0.0	31
46.00	30.9	39.6	29.4	33.4	39.1	27.5	0.86												
47.00	25.8	38.9	35.3	28.0	38.6	33.3	0.68					55.3	37.1	1.9	1.2	2.3	2.1	0.0	477
48.00	29.7	37.3	33.0	32.2	37.2	30.6	0.76	12.8				63.3	29.9	1.8	1.8	0.9	1.8	0.3	324
49.00	26.8	41.0	32.2	29.3	40.7	30.1	0.84	12.5				57.3	31.4	1.7	6.8	1.4	1.4	0.0	427
50.00	28.6	37.8	33.6	31.0	37.9	31.1	0.72	12.3				56.0	37.8	1.9	0.3	1.9	1.3	0.8	373
51.00	34.2	32.9	32.8	36.8	32.7	30.5	0.62	14.0				61.4	24.6	1.8	3.5	1.8	7.0	0.0	57
52.00								13.5											
53.00								11.9				63.6	32.0	0.4	3.6	0.4	0.0	0.0	250
54.00								14.2											
55.00								16.2											
56.00								17.8											
57.00								22.6											
58.00								16.2											
59.00								16.0											

77 SR 25

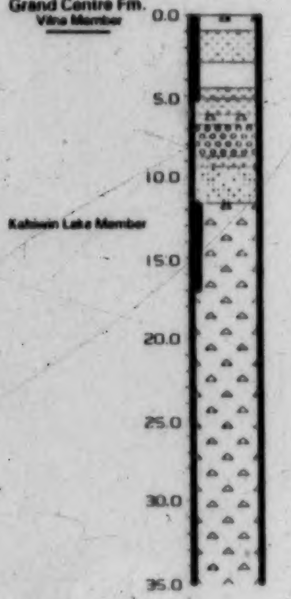
Alberta Geological Survey Testhole 77 SR 25
Location S of LSD 6 Sec 29 Twp 68 Rng 9 W of 4 Mer . NTS 73L
Elevation 1815 Ft . 553 M Source 1 50,000 NTS 73L/14
Date drilled 197708.24 Logged by: C LUTZAK



DEPTH	TEXTURE (%)							H2O	MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						N
(M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	(%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METH	QTZ	QTZT QSS	LST	DST	LOC	OTH	
1.00								14.8				70.6	25.1	1.7	0.3	0.0	2.3	0.0	299
2.00	20.4	44.0	35.6	21.7	38.4	39.8	0.57	17.8				63.5	20.3	3.4	5.4	6.7	0.7	0.0	148
3.00	0.8	52.4	46.8	0.9	45.5	53.6	0.00	21.6											
4.00	28.6	38.0	33.4	30.6	31.4	38.0	0.96	14.0				55.9	25.6	2.8	7.8	7.8	0.0	0.0	281
5.00	38.0	33.3	28.7	40.4	27.6	31.9	2.34	12.7				75.1	19.6	0.5	2.4	1.6	0.8	0.0	377
6.00	36.9	32.7	30.4	39.3	26.6	34.1	2.03	13.0				66.1	26.7	1.7	0.9	2.9	1.7	0.0	419
7.00	39.5	29.0	31.4	42.0	22.8	35.2	2.07	12.2				73.2	23.3	0.4	1.1	1.4	0.2	0.2	437
8.00	24.5	42.7	32.8	26.1	36.9	37.0	1.12	14.9				61.9	25.9	2.4	2.7	3.2	2.7	1.3	375
9.00	17.8	35.9	46.3	20.2	29.6	50.2	0.47	23.8				66.3	14.8	1.7	1.7	1.7	13.7	0.0	175
10.00	24.3	33.4	42.3	26.5	27.4	46.1	0.68	15.6				68.4	24.5	0.7	1.1	3.2	1.1	0.0	281
11.00	37.4	31.5	31.1	40.1	25.4	34.5	1.55	16.1				63.4	24.3	1.6	1.6	1.3	7.8	0.0	445
12.00	45.6	30.8	23.7	48.0	24.9	27.1	0.84	13.0				68.7	19.4	1.9	1.1	2.8	6.0	0.0	464
13.00	48.2	25.6	26.1	50.4	20.0	29.6	1.10	12.0				67.7	23.7	1.0	1.9	2.7	2.9	0.0	511
14.00	46.9	28.2	24.9	49.0	23.0	28.0	0.84	11.1				67.7	23.2	1.8	0.4	1.4	5.4	0.0	276
15.00	48.2	29.9	21.9	50.6	24.5	24.9	3.10	12.3											
16.00	38.9	31.4	29.7	41.3	24.6	34.1	1.51												
17.00	54.2	24.1	21.6	56.3	19.5	24.2	3.29												
18.00	26.0	43.6	30.4	29.4	36.7	33.9	0.84					60.6	23.0	9.7	0.0	0.0	6.7	0.0	165
19.00	26.0	37.8	36.2	29.4	30.6	40.0	0.69	12.3				54.2	28.3	9.0	0.0	0.6	7.7	0.0	155
20.00	27.6	51.4	21.0	31.9	44.0	24.1	0.74					54.7	27.0	16.2	0.0	0.0	2.0	0.0	148
21.00	49.1	36.6	14.3	52.6	30.4	17.0	8.03	15.4											
22.00	50.1	26.9	23.0	53.1	21.2	25.7	2.19					66.9	29.8	0.2	0.3	0.0	2.8	0.0	571
23.00	36.2	33.8	30.1	38.3	27.1	34.6	0.94	15.2				61.7	34.1	3.3	0.0	0.0	0.8	0.0	489
24.00	25.0	46.8	28.2	28.6	40.0	31.4	1.23	12.9											
25.00	13.4	62.7	23.9	16.3	56.5	27.2	0.87												
26.00	28.5	43.4	28.1	31.6	37.6	30.8	1.02												
27.00	37.0	37.8	25.2	39.5	32.2	28.3	1.58												
28.00	15.9	53.4	30.7	18.1	47.4	34.5	0.60												
29.00	23.0	47.5	29.5	26.1	41.0	32.9	0.90												
30.00	11.2	59.6	29.3	14.8	52.8	32.4	0.23					49.3	12.3	27.4	0.0	0.0	10.9	0.0	73
31.00	18.6	54.5	26.9	22.2	47.8	30.0	0.43	13.3											
32.00	18.5	53.9	27.6	22.1	47.2	30.8	0.37												

77 SR 26

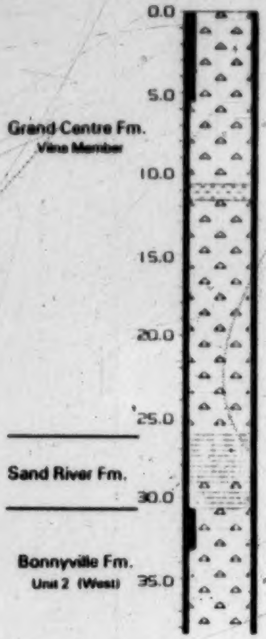
Alberta Geological Survey Testhole 77 SR 26
Location of LSD 2 Sec 8 Twp 68 Rng 10 W of 4 Mer., NTS 73L
Elevation 2345 Ft 715 M Source 1 50,000 NTS 73L/14
Date drilled 197708 29 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								18.5				78.7	18.0	0.4	1.7	2.7	0.4	0.0	478
5.00								21.6											
6.00								15.2				77.0	19.2	0.3	0.7	2.7	0.0	0.0	291
12.00	32.7	35.3	32.0	35.2	34.2	30.6	1.48	14.8				76.4	18.5	1.1	1.1	2.9	0.0	0.0	279
13.00	37.3	31.2	31.5	39.8	30.1	30.2	2.12	14.0				72.0	23.2	0.2	0.9	3.5	0.2	0.0	453
14.00	42.4	30.0	27.6	45.1	28.5	26.4	2.29	14.0				71.2	21.6	1.0	2.4	2.8	1.0	0.0	496
15.00	42.7	30.8	26.5	45.5	29.0	25.4	2.40	13.3				71.9	21.2	0.0	1.4	2.9	2.5	0.0	278
16.00	43.1	30.6	26.1	46.1	29.0	24.9	2.50	13.4				69.4	23.9	0.2	2.2	3.6	0.4	0.0	448
17.00	42.8	32.2	25.0	45.5	30.9	23.6	2.58	12.9				64.3	28.7	0.5	1.6	4.0	0.8	0.0	373
18.00								12.6				67.6	23.9	1.0	2.5	3.2	1.4	0.3	284
19.00	42.6	33.5	24.0	45.3	32.0	22.6	2.47	12.7				72.9	20.9	0.0	1.8	3.7	0.4	0.4	273
20.00								11.9				66.9	24.1	1.5	3.0	3.7	0.7	0.0	266
21.00	42.3	34.0	23.7	45.0	32.8	22.3	2.53	12.7				69.7	24.0	0.4	1.7	3.3	0.9	0.0	521
22.00								12.0				73.6	21.0	0.8	1.6	2.2	0.8	0.0	367
23.00	40.6	37.5	21.9	43.6	36.0	20.5	2.37	12.8				70.3	23.7	0.3	3.1	0.8	1.3	0.5	380
24.00								12.0				66.5	25.6	1.5	1.9	1.9	2.2	0.4	266
25.00	41.0	33.7	25.3	43.9	32.5	23.6	2.31	12.7				68.8	26.8	0.2	2.2	1.2	0.2	0.5	414
26.00								12.4				65.7	26.0	0.9	1.1	3.4	2.5	0.2	434
27.00	42.6	33.8	23.6	45.3	32.6	22.1	2.29					71.8	23.4	0.5	1.9	1.9	0.5	0.0	372
28.00								12.2				62.8	30.1	1.1	2.6	3.3	0.0	0.0	269
29.00	41.9	33.5	24.6	44.9	31.9	23.2	2.17	12.6				66.2	27.9	0.0	1.3	3.5	1.1	0.0	459
30.00								12.4				68.8	23.2	0.8	2.5	2.5	1.4	0.7	439
31.00	40.1	32.2	27.6	43.0	30.8	26.1	2.08	11.8				70.4	25.4	1.1	1.1	0.8	0.4	0.8	260
32.00	40.8	33.3	26.0	43.6	31.9	26.4	2.14	12.2				67.0	27.0	0.2	2.1	2.8	0.8	0.0	385
33.00	40.8	33.8	25.3	43.7	32.5	23.8	2.22	11.8				72.4	22.4	0.4	1.5	2.2	0.7	0.4	272
34.00	37.2	38.1	24.7	40.3	36.8	22.9	1.83	12.3				63.1	31.4	0.5	1.7	2.2	0.7	0.2	404
35.00	42.2	33.0	24.8	45.1	31.6	23.4	2.41	11.4				62.7	30.0	0.8	1.5	4.2	0.4	0.4	263

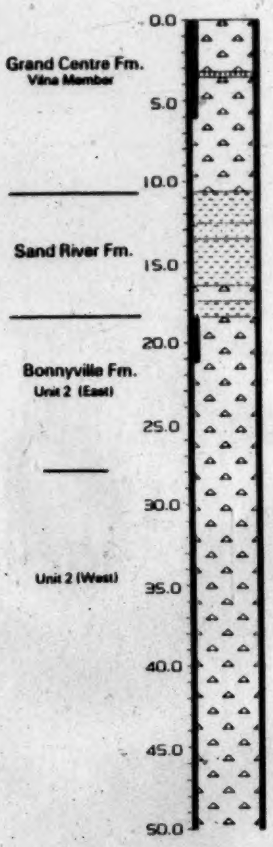
77 SR 27

Alberta Geological Survey Testhole 77 SR 27
Location NE of LSD 2 Sec 36 Twp 67 Rng 12 W of 4 Mer . NTS 73L
Elevation 2055 Ft 627 M Source 1:50,000 NTS 73L/13
Date drilled 197708 13 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)					
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00								14.7				69.8	25.2	2.1	0.0	0.4	1.7	0.4	242
2.00	23.3	39.7	37.0	25.5	39.4	35.1	0.51	14.9				69.6	21.2	2.4	4.8	1.2	0.8	0.0	250
3.00	16.1	46.0	37.9	18.0	46.1	35.9	0.33	16.8				71.8	18.8	1.9	2.3	0.5	0.5	0.0	213
4.00	20.2	41.8	38.0	22.4	41.2	36.5	0.68	16.3				61.7	31.1	3.0	3.0	0.9	1.3	0.0	235
5.00	16.4	44.0	39.5	18.0	44.9	37.1	0.35	16.9				73.7	17.5	2.9	2.2	2.2	1.5	0.0	137
6.00	19.8	41.8	38.4	21.7	42.1	36.2	0.50	14.0				67.2	18.9	3.0	4.0	3.3	3.0	0.0	302
7.00								13.1				64.4	26.3	2.2	2.2	2.7	1.4	0.0	407
8.00	25.6	37.0	37.4	27.9	36.5	35.6	0.72	13.7				64.0	24.5	2.4	2.4	2.1	4.5	0.0	331
9.00								13.8				65.8	26.6	1.4	2.2	3.2	0.0	0.7	278
10.00	20.6	38.8	40.6	22.6	38.9	38.5	0.60	12.9				71.3	19.5	4.2	2.9	1.0	2.6	0.7	307
11.00								15.2											
12.00								9.9				66.7	28.0	2.2	0.6	1.9	0.6	0.3	323
13.00	29.8	40.9	29.3	32.7	39.5	27.9	1.21	12.0				68.0	23.7	1.2	2.7	2.7	1.5	0.3	337
14.00	21.3	43.2	35.5	23.6	43.0	33.3	0.58	13.7				65.2	21.6	2.5	3.9	1.1	5.0	0.0	282
15.00								12.4				55.4	29.1	2.8	6.3	4.2	1.7	0.4	285
16.00								13.2				61.1	25.5	3.2	3.2	4.6	2.1	0.0	411
17.00	28.3	39.1	32.6	30.3	39.0	30.8	0.84	14.0				60.0	23.5	4.0	4.4	3.7	3.7	0.7	430
18.00								14.4				68.8	17.4	2.1	4.9	3.4	3.1	0.3	384
19.00	33.8	36.1	30.1	36.2	35.5	28.3	1.25	13.4				68.3	15.0	2.0	6.7	5.3	1.6	1.0	505
20.00								12.2				62.9	21.5	2.6	6.6	3.0	3.3	0.0	302
21.00	31.4	38.4	30.2	33.7	37.9	28.4	0.88	14.0				62.2	26.9	1.1	4.3	4.3	0.5	0.0	368
22.00								14.0				68.1	21.0	1.5	2.8	3.9	2.4	0.3	386
23.00	31.4	33.7	34.9	33.7	32.9	33.4	1.04	12.1				61.1	26.1	1.3	4.4	5.0	2.1	0.0	383
24.00	28.5	36.7	34.8	30.5	36.0	33.5	1.04	11.8				66.8	21.0	1.6	3.8	4.1	2.8	0.0	319
25.00								19.4				72.5	22.5	3.0	1.0	0.0	1.0	0.0	102
26.00								22.0											
27.00								19.7											
28.00								23.6											
29.00								21.7											
30.00								18.5											
31.00	44.9	29.2	25.9	47.3	27.6	25.2	2.98	11.8				65.7	30.1	0.0	1.0	2.6	0.6	0.0	312
32.00	40.3	32.8	26.9	42.8	31.4	25.8	2.61	12.5				67.8	20.5	0.5	2.9	3.1	5.3	0.0	419
33.00	39.0	33.1	27.9	41.5	27.5	31.1	2.67	12.2				70.4	21.2	0.0	2.6	3.8	2.0	0.0	345
34.00	36.2	35.5	28.3	38.6	30.0	31.4	2.45	11.7				63.8	26.5	0.7	3.4	3.0	2.7	0.0	298
35.00	34.7	36.9	28.4	37.2	31.4	31.4	2.03	11.1				55.2	32.4	0.2	3.7	5.6	2.4	0.4	460
36.00	34.1	37.2	28.7	36.5	31.4	32.0	1.84	12.0				61.1	28.1	0.2	4.2	4.2	1.5	0.7	455
37.00	33.9	37.7	28.4	36.4	32.2	31.4	1.92	12.1				69.9	20.8	0.7	3.6	2.9	1.9	0.7	418

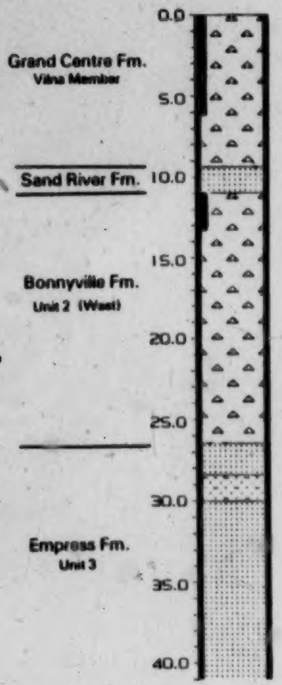
77 SR 28



Alberta Geological Survey Testhole 77 SR 28
Location of LSD 10 Sec 22 Twp 69 Rng 11 W of 4 Mer . NTS 73L
Elevation 2070 Ft 631 M Source 1 50,000 NTS 73L/13
Date drilled 1977/10 27 Logged by M FENTON

DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	20.5	28.6	50.9	22.3	34.3	43.3	0.64												
2.00	21.5	34.0	44.5	24.1	38.3	37.6	0.86	8.0				70.1	25.3	0.4	2.3	1.1	0.8	0.0	261
3.00	22.9	28.4	48.8	25.0	32.8	42.2	0.99					68.2	25.0	1.6	2.4	2.4	0.4	0.0	252
4.00	35.0	31.7	33.4	38.6	32.8	28.6	0.88					68.8	26.5	1.1	1.4	1.4	0.9	0.0	362
5.00	19.5	38.2	42.3	22.4	41.3	36.3	0.29					60.1	31.0	1.5	4.4	2.6	0.4	0.0	271
6.00	22.8	38.7	38.4	25.7	42.4	31.9	0.72					62.9	26.7	2.7	3.0	3.0	1.5	0.0	329
7.00	22.2	29.1	48.7	24.4	38.3	37.3	0.84					60.9	29.1	1.4	3.1	2.1	2.3	1.0	289
8.00	21.6	28.3	50.1	24.1	37.2	38.7	0.68												
9.00	21.2	29.1	49.7	23.3	37.6	39.1	0.80	7.1				61.2	28.2	1.7	3.6	1.9	3.3	0.0	358
10.00	20.7	31.2	48.0	22.7	42.0	35.3	0.69					60.9	31.6	0.7	2.7	1.7	2.1	0.3	297
17.00	22.1	37.4	40.5	25.1	44.5	30.4	0.59					64.0	26.6	1.0	2.6	2.3	3.1	0.0	391
19.00	47.6	21.6	30.8	50.4	23.2	26.4	2.47	9.7				63.8	29.4	0.0	2.0	3.6	1.2	0.0	500
20.00	46.8	22.1	31.0	49.5	24.4	26.0	2.56	9.6				64.7	28.7	0.5	2.0	3.9	0.2	0.0	558
21.00	46.6	25.3	28.1	49.3	27.6	23.1	1.94	9.3				62.1	31.8	0.2	2.6	2.6	0.4	0.2	493
22.00	50.0	23.4	26.6	53.0	25.8	21.2	2.82	9.8				65.4	27.1	0.4	2.6	3.2	1.2	0.0	495
23.00								9.3				61.6	30.9	0.8	3.0	2.5	0.8	0.2	469
24.00	43.5	26.5	30.0	46.1	31.1	22.8	0.29	9.6				65.6	25.4	0.4	2.9	4.7	0.6	0.2	445
25.00								9.2				66.3	28.2	0.0	2.0	3.0	0.6	0.0	504
26.00	44.5	26.6	28.9	47.1	31.5	21.4	1.97	9.8				59.9	32.8	0.5	1.4	4.2	0.9	0.2	549
27.00								10.6				65.4	29.3	0.2	2.3	2.1	0.8	0.0	529
28.00	38.2	25.0	36.8	41.1	31.2	27.7	2.01	10.9				66.6	29.3	0.3	0.5	1.6	1.6	0.0	368
29.00								11.0				68.4	27.5	0.0	1.7	1.7	0.6	0.0	342
30.00	33.2	25.9	41.0	35.9	32.3	31.8	1.66	11.3				63.2	28.9	0.3	2.1	3.7	0.9	0.0	356
31.00								10.5				58.8	34.1	0.8	2.3	2.8	1.1	0.0	352
32.00	36.1	26.3	37.6	39.0	30.9	30.1	1.78	11.4				56.2	38.0	0.3	2.0	1.4	2.0	0.0	347
33.00								11.3				56.9	32.9	2.1	3.0	2.7	2.1	0.3	371
34.00	34.7	26.0	39.3	37.5	32.3	30.2	1.24	11.5				56.8	35.5	1.7	3.0	1.9	1.0	0.0	470
35.00								13.0				56.8	33.7	0.8	2.8	2.8	1.8	1.1	359
36.00	36.8	28.6	34.5	39.4	34.8	25.8	1.88	10.9				58.8	35.8	0.2	2.5	2.0	0.4	0.2	405
37.00								11.1				62.4	28.9	0.3	5.4	2.7	0.3	0.0	370
38.00	36.3	28.8	34.8	39.0	35.5	25.6	1.52	10.2				65.0	30.3	0.3	2.3	1.4	0.6	0.0	352
39.00								10.6				63.0	29.0	0.0	4.1	2.3	0.9	0.6	341
40.00	37.3	24.9	37.8	40.0	29.8	30.1	1.69	9.7				59.7	34.3	0.3	2.1	2.7	0.9	0.1	747
41.00								10.0				61.5	33.7	1.0	1.4	1.2	1.0	0.0	637
42.00	34.5	29.5	36.0	37.3	34.1	28.6	1.57	11.7				60.6	32.5	0.8	2.2	2.2	1.8	0.0	508
43.00								10.7				64.7	29.2	0.7	2.3	1.8	1.3	0.0	603
44.00	36.3	29.2	34.5	39.0	34.3	26.7	1.86	10.6				64.2	26.9	0.5	3.1	4.0	1.0	0.2	573
45.00												64.6	27.4	0.0	3.1	2.8	1.8	0.3	325
46.00	41.1	27.8	31.1	43.6	31.8	24.6	2.51					65.9	27.2	0.0	1.5	4.5	0.9	0.0	463
47.00	39.3	23.9	36.8	41.8	30.6	27.6	1.89					61.6	32.4	0.0	2.1	3.4	0.4	0.0	386
48.00	39.7	23.3	37.0	42.2	28.9	28.9	1.90					61.5	29.3	0.6	2.5	4.9	1.2	0.0	525
49.00	40.6	23.9	35.5	43.3	29.1	27.6	2.53					61.1	33.3	0.3	1.8	3.2	0.3	0.0	339
50.00	41.0	25.6	33.4	43.4	30.8	25.8	1.85					67.0	23.6	0.9	2.9	4.5	0.9	0.2	555

77 SR 29

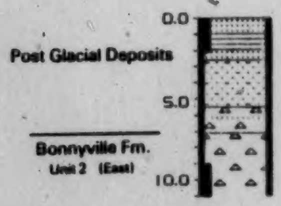


Alberta Geological Survey Testhole 77 SR 29
Location of LSD 8 Sec 2 Twp 69 Rng 13 W of 4 Mer . NTS 73L
Elevation 1920 Ft 585 M Source 1 50,000 NTS 73L/13
Date drilled 197710 28 Logged by M FENTON

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN. METM	QTZ	QTZT QSS	LST	DST	LOC	DTM	N
1.00	35.6	27.0	37.5	38.2	30.7	31.1	1.67	11.9				68.6	23.0	0.3	3.3	2.5	1.5	0.0	395
2.00	36.7	27.1	36.2	39.2	30.9	30.0	1.97	11.9				69.4	24.1	0.5	1.6	1.6	2.7	0.0	373
3.00	34.7	35.6	29.7	37.3	38.9	23.9	2.50	13.5				72.8	20.8	0.0	2.1	1.9	2.5	0.0	481
4.00	38.5	28.7	32.8	41.0	31.4	27.6	2.33	10.7				74.6	18.2	0.3	2.3	3.3	1.0	0.0	307
5.00	37.9	50.8	11.3	40.5	51.0	8.5	2.15	10.9				68.7	24.4	0.0	2.8	1.6	2.4	0.0	499
6.00	31.7	38.1	30.2	34.1	44.9	21.0	1.45	11.1				72.2	19.4	0.3	2.9	1.9	3.2	0.0	309
7.00	34.4	39.7	26.0	36.9	45.8	17.3	1.87	12.1				64.6	24.2	0.4	3.8	1.7	4.6	0.8	240
8.00	20.0	46.5	33.5	22.3	54.2	23.5	0.53	12.1				65.9	23.5	2.4	2.4	1.2	11.8	1.2	85
9.00	33.9	45.0	21.1	36.3	49.8	13.9	1.25	9.9				68.1	24.8	0.6	2.1	2.8	1.2	0.2	467
10.00								10.1				61.8	30.9	0.5	3.8	2.4	0.5	0.0	372
11.00	39.3	26.5	34.2	41.8	30.0	28.3	2.04	10.1				64.8	30.1	0.4	1.8	2.0	0.9	0.0	551
12.00	38.6	30.7	30.7	41.2	34.4	24.4	2.79	9.6				64.5	27.2	0.2	3.7	2.4	1.0	0.0	493
13.00	39.9	39.5	20.6	42.4	45.0	12.6	2.21	9.3				65.7	28.0	0.2	2.4	3.0	0.7	0.0	539
14.00	39.3	36.8	23.9	42.1	42.5	15.4	2.37	9.8				61.2	29.1	0.6	3.4	2.4	2.8	0.2	467
15.00								9.8				58.9	33.8	0.6	3.8	1.6	0.8	0.0	506
16.00	40.1	36.9	23.0	42.6	42.6	14.8	2.27	10.1				54.9	36.1	1.3	1.3	4.0	1.5	0.0	399
17.00								10.2				60.6	30.6	0.7	3.4	4.0	0.7	0.7	297
18.00	38.0	37.1	24.8	40.5	43.2	16.3	2.00	11.1				58.1	34.6	0.3	1.6	4.4	1.0	0.0	384
19.00								11.1				59.7	31.8	0.5	3.4	3.6	1.0	0.0	412
20.00	35.2	32.3	32.6	37.7	36.5	25.7	1.88	10.8				59.8	31.8	0.2	3.3	5.1	1.4	0.0	428
21.00								9.3				58.2	36.7	0.2	2.7	1.2	1.0	0.2	411
22.00	37.0	32.5	30.5	39.4	38.8	21.7	1.64	9.3				59.4	35.2	0.5	1.5	2.2	1.0	0.2	401
23.00	36.7	36.0	27.3	39.2	41.8	18.9	1.68	10.1				58.5	31.8	0.9	5.1	3.0	1.5	0.3	334
24.00	39.8	31.4	28.7	42.2	38.1	19.7	1.88	14.7				61.1	32.4	0.5	0.8	4.5	0.8	0.0	398
25.00	41.0	36.8	22.3	43.3	42.3	14.3	2.02	9.8				68.3	26.5	0.4	1.7	1.9	1.5	0.2	479
26.00	42.2	32.8	25.0	44.6	38.2	17.1	2.49	9.4				66.0	28.5	0.5	1.6	3.0	0.7	0.0	438
28.00								13.1				68.0	37.9	1.8	0.9	0.5	0.9	0.0	219

77 SR 30

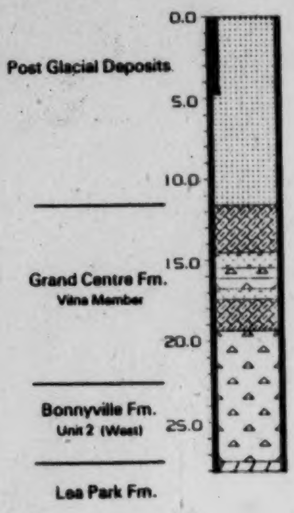
Alberta Geological Survey Testhole 77 SR 30
Location SW of LSD 14 Sec 22 Twp 69 Rng 12 W of 4 Mer . NTS 73L
Elevation ≈1920 Ft. 585 M Source 1:50,000 NTS 73L/13
Date drilled 197710 30 Logged by M FENTON



DEPTH (M)	TEXTURE (%) SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METH	COARSE SAND LITHOLOGY (%) QTZ	QTZT OSS	LST	DST	LOC	OTH	N
1.00								16.6				65.6	28.1	1.6	0.8	2.3	1.6	0.0	128
3.00								13.5				65.7	28.0	0.0	1.2	2.8	2.2	0.3	324
4.00								19.4				81.8	18.2	0.0	0.0	0.0	0.0	0.0	22
5.00								17.8				81.3	17.8	0.0	0.0	0.9	0.0	0.0	107
7.00	42.5	39.5	18.0	46.8	41.4	11.8	1.29	9.9				66.6	24.7	0.0	1.5	5.7	1.2	0.0	332
8.00	49.0	29.0	22.0	51.8	33.3	14.9	2.12	10.4				61.9	30.0	0.8	1.6	3.7	1.2	0.0	491
9.00	43.5	28.0	28.5	46.1	32.3	21.6	1.73	10.7				60.9	32.8	0.6	1.1	1.7	2.3	0.3	348
10.00	45.4	27.2	27.5	48.1	30.8	21.1	1.73	10.1				57.9	36.8	1.1	0.5	1.3	2.4	0.0	378
11.00	46.5	34.4	19.1	49.1	38.1	12.8	1.75	9.9				63.3	30.3	1.6	0.5	1.6	2.5	0.2	436

77 SR 31

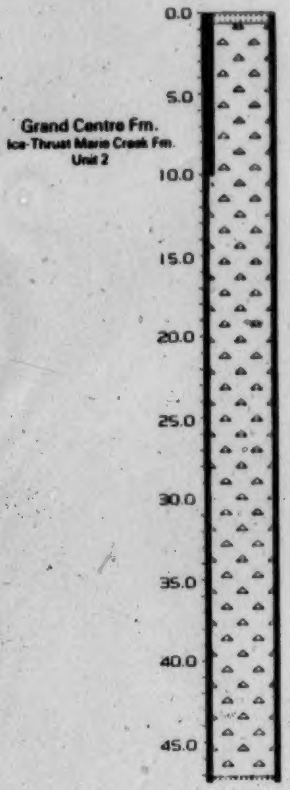
Alberta Geological Survey Testhole 77 SR 31
Location: SW of LSD 2 Sec 31 Twp 69 Rng 13 W of 4 Mer , NTS 73L
Elevation: 1860 Ft 567 M Source 1 50,000 NTS 73L/13
Date drilled 197710 30 Logged by M FENTON



DEPTH (M)	TEXTURE (%) SAND >62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT QSS	LST	DST	LOC	OTH	N
2.00								5.7											
3.00								9.7											
4.00								18.5											
5.00								19.3											
6.00								21.9											
7.00								20.7											
8.00								18.3											
9.00								20.8											
10.00								19.0				40.4	40.4	2.0	0.0	0.0	17.2	0.0	151
11.00								19.1				51.5	43.8	2.1	0.0	1.3	0.8	0.4	235
12.00	14.3	39.1	46.5	16.2	50.8	33.0	0.22	20.7				66.2	28.2	0.0	0.0	5.6	0.0	0.0	71
13.00								18.4				62.6	25.7	0.5	4.8	2.4	3.4	0.0	206
14.00								17.3				51.8	24.7	0.0	9.9	9.9	3.7	0.0	81
16.00	5.8	57.1	37.1	7.6	67.6	24.8	0.12	17.4				66.0	26.0	0.0	4.0	0.0	2.0	0.0	50
17.00								16.1				57.1	28.6	4.8	9.5	0.0	0.0	0.0	21
18.00								12.1				58.6	29.8	3.7	2.1	4.2	1.6	0.0	191
19.00								16.3				40.9	47.3	2.1	5.4	2.1	2.1	0.0	93
20.00	46.3	19.1	34.6	48.2	24.9	26.9	2.33	10.3				61.1	30.4	0.6	2.0	5.5	0.3	0.0	342
21.00	29.4	33.7	37.0	31.9	41.3	26.8	1.52	11.5				61.2	32.8	0.7	1.9	2.6	0.5	0.0	415
22.00	28.9	36.6	34.5	32.1	42.7	25.2	1.43	11.0				59.8	33.0	0.7	2.6	2.8	0.7	0.0	575
23.00	40.1	32.0	27.9	42.7	37.1	20.3	2.65	15.8				60.5	31.6	1.3	2.6	2.3	0.9	0.6	307
24.00	39.8	31.8	28.4	42.4	37.6	20.0	2.39	9.0				61.7	31.6	0.6	3.2	2.0	0.9	0.0	342
25.00	38.4	32.7	29.0	41.0	38.7	20.3	2.59	9.5				58.2	35.8	0.2	2.7	2.4	0.7	0.0	589
26.00	34.8	33.0	32.2	37.4	39.2	23.4	1.67	11.4				51.6	39.7	0.8	3.4	3.4	0.7	0.0	589
27.00	24.7	38.0	37.3	27.2	45.3	27.5	0.78												
28.00								15.7											
29.00								17.6											

77 SR 33

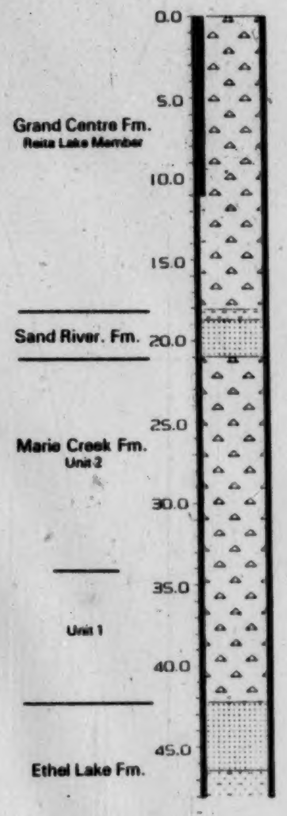
Alberta Geological Survey Testhole 77 SR 33
Location: of LSD 4 Sec 27 Twp 65 Rng 7 W of 4 Mer , NTS 73L
Elevation: 2455 Ft 748 M Source 1 50,000 NTS 73L/10
Date drilled: 197807 14 Logged by: ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE			COARSE SAND LITHOLOGY (%)							
DEPTH (M)	SAND >62.5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT QSS	LST	DST	LOC	OTH	N
1.00	47.2	17.8	35.0	49.7	20.7	29.7	1.25	12.4				73.3	24.7	1.6	0.0	0.0	0.4	0.0	255
2.00	51.0	22.3	26.7	53.4	25.4	21.2	3.53	11.8				67.7	25.0	0.0	1.7	4.1	1.5	0.0	523
5.00	46.7	25.9	27.4	49.4	28.6	22.0	2.85	10.1				60.5	27.6	0.3	2.7	6.6	1.7	0.0	301
6.00								11.4				67.8	21.1	0.0	3.4	5.7	2.0	0.0	351
7.00	46.4	24.6	29.0	49.0	28.0	23.0	2.80	11.2				64.7	21.5	0.3	2.0	10.2	1.4	0.0	391
8.00								10.6				60.3	26.2	0.0	4.7	7.9	0.9	0.0	466
9.00	45.7	25.9	28.4	48.4	28.7	22.8	2.48	10.8				62.5	26.5	0.0	2.5	7.1	1.7	0.0	408
10.00								10.6				63.4	21.1	0.6	3.7	10.4	0.8	0.0	355
11.00	43.6	28.0	28.4	46.4	32.6	21.0	2.93	10.6				62.1	22.4	0.0	3.0	11.4	1.1	0.0	464
12.00								11.3				64.0	12.9	0.3	3.5	17.0	2.3	0.0	311
13.00	39.3	30.0	30.7	42.5	35.3	22.2	3.06	10.6				66.4	18.4	0.6	2.5	11.1	1.0	0.0	396
14.00								10.7				61.6	15.9	0.3	4.0	16.9	1.3	0.0	372
15.00	39.0	28.0	32.9	41.8	34.9	23.2	2.85	10.4				68.0	26.3	0.2	1.4	1.8	1.0	0.0	438
16.00								9.8				61.6	28.9	0.0	2.6	3.9	2.1	0.5	380
17.00	44.7	26.7	28.6	47.4	32.1	20.5	2.65	10.5				64.5	24.1	0.3	2.6	5.7	2.8	0.0	349
18.00								10.2				64.3	28.3	0.0	3.1	3.9	0.4	0.4	258
19.00	43.5	27.7	28.8	46.0	34.3	19.7	2.75	10.4				56.5	28.8	0.0	3.5	8.8	1.9	0.4	260
20.00	45.9	25.4	28.7	48.7	31.6	19.7	2.92	9.9				61.7	26.2	0.0	2.8	7.6	2.2	0.0	317
22.00	43.9	24.4	31.6	46.5	30.7	22.8	2.71	10.0				67.3	22.3	0.0	2.4	5.6	2.2	0.5	413
23.00	44.8	26.4	28.8	47.6	32.4	20.0	2.93	10.1				59.9	28.6	0.0	2.4	7.5	1.2	0.3	329
24.00								10.1				67.0	22.1	0.0	2.7	5.2	2.7	0.3	367
25.00	44.6	28.1	27.3	47.3	33.1	19.7	2.53	9.4				62.3	26.5	0.0	2.2	7.3	1.3	0.3	313
26.00								9.9				67.0	20.8	0.0	2.5	7.5	1.8	0.7	279
27.00	44.4	26.5	29.2	46.9	32.2	20.8	2.64	9.8				66.0	25.1	0.0	2.1	5.8	1.0	0.0	382
28.00								9.5				63.9	23.9	0.0	3.1	8.2	0.8	0.0	295
29.00	42.7	26.2	31.1	45.3	32.0	22.7	2.56	8.9				64.4	23.2	0.0	4.8	6.3	1.0	0.0	315
30.00								9.3				67.1	17.8	0.2	5.8	6.3	2.8	0.0	416
31.00	44.3	27.2	28.5	46.8	31.5	21.7	2.84	8.9				62.5	26.0	0.0	1.3	8.6	1.6	0.0	304
32.00								9.8				63.8	25.5	0.3	2.1	7.4	0.9	0.0	337
33.00	45.2	25.3	29.4	47.8	29.1	23.2	2.39	12.8				65.2	21.1	0.5	4.3	8.2	0.5	0.5	417
34.00								9.6				62.4	26.5	0.0	1.7	7.8	1.7	0.0	351
35.00	44.6	26.5	28.8	47.5	31.0	21.5	2.81	8.6				66.1	23.9	0.0	3.7	5.6	0.8	0.0	251
36.00								9.2				61.1	24.6	0.3	1.8	11.6	0.8	0.0	388
37.00	43.0	31.1	25.8	46.4	34.5	19.1	3.03	9.6				62.8	24.0	0.3	2.5	9.3	1.1	0.0	366
38.00								10.0				60.9	19.2	0.0	4.7	13.4	1.8	0.0	276
39.00	40.5	29.6	29.9	43.2	34.9	21.8	2.58	9.9				63.0	17.3	0.0	1.4	16.6	0.7	0.0	289
40.00								9.8				61.3	23.5	0.8	4.6	7.5	2.3	0.0	388
41.00	42.7	29.7	27.7	45.3	34.5	20.2	0.00	10.0				63.7	22.9	0.3	2.1	9.5	1.5	0.0	336
42.50	52.7	23.0	24.3	55.4	27.0	17.5	4.69					62.5	23.5	0.0	1.9	10.5	1.6	0.0	315
44.00	50.7	28.4	20.9	54.2	29.8	16.0	3.01												
45.00								9.7											

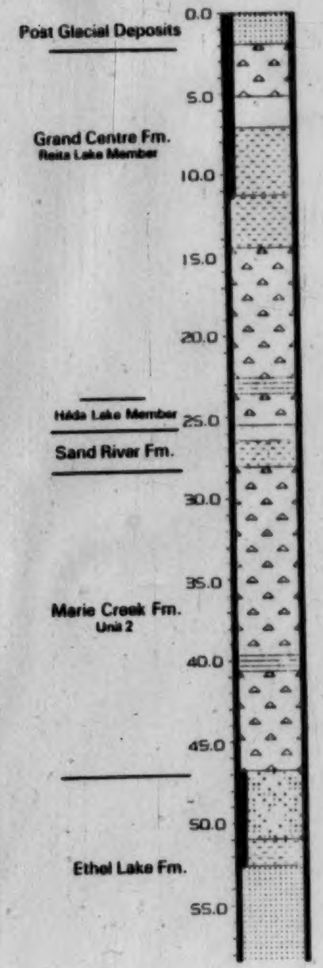
77 SR 34

Alberta Geological Survey Testhole 77 SR 34
Location: .of LSD 16 Sec 20 Twp 66 Rng 5 W of 4 Mer , NTS 73L
Elevation 2115 Ft 645 M Source 1 50,000 NTS 73L/10
Date drilled 197807 14 Logged by ANDRIASHEK



	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND >62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1-2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/DO	IGN METM	QTZ	QTZT USS	LST	DST	LOC	OTH	N
1.00	44.3	23.7	31.9	46.8	22.8	30.4	1.80	10.9				76.5	16.0	1.1	2.2	3.4	0.8	0.0	268
2.00								3.2				74.2	20.7	0.4	2.0	2.0	0.8	0.0	256
3.00	45.3	20.1	34.6	47.9	20.0	32.1	1.46	11.2				67.2	22.0	2.8	2.9	4.4	1.3	0.0	454
4.00								11.4				66.8	25.8	1.2	1.7	2.8	1.9	0.0	422
5.00	23.3	26.3	50.4	25.1	28.7	46.1	1.14	12.8				68.6	23.5	0.7	3.5	2.0	2.0	0.0	456
6.00								12.5				72.1	17.2	1.7	2.3	5.9	1.1	0.0	355
7.00	19.9	42.0	38.2	22.1	42.4	35.5	2.54	11.6				71.4	21.0	1.4	1.1	3.4	1.1	0.0	357
8.00								11.8				72.0	18.9	0.2	1.5	5.7	1.5	0.2	460
9.00	44.0	21.2	34.8	46.4	21.2	32.5	2.71	10.7				69.6	22.0	1.1	2.7	3.8	0.5	0.0	368
10.00	37.5	24.6	38.0	39.6	24.4	35.9	1.97	10.7				68.8	23.1	0.3	0.9	4.7	2.2	0.0	321
11.00	45.0	22.3	32.7	47.4	21.8	30.7	3.05	10.7				73.5	19.4	0.0	3.0	2.8	0.2	0.7	427
12.00	47.3	25.4	27.3	50.0	25.1	25.0	3.37	9.5				70.0	24.4	0.0	2.6	2.6	0.3	0.0	307
13.00	46.8	22.3	30.9	49.3	23.1	27.7	3.80	10.3				72.2	22.2	0.4	1.5	1.9	1.5	0.4	266
14.00								9.5				68.4	27.0	0.0	0.4	2.0	0.0	0.0	256
15.00	53.3	22.9	23.8	56.2	21.9	22.0	4.80	10.1				70.0	22.1	0.5	2.4	2.1	3.1	0.0	420
16.00								6.1				67.4	25.9	0.0	1.7	1.0	3.7	0.3	301
17.00	42.5	26.4	31.1	45.2	26.9	27.9	4.08	12.8				69.9	23.9	0.3	1.2	1.8	3.0	0.0	335
18.00								18.1											
19.00																			
22.00	36.1	31.4	32.5	38.5	33.2	28.2	2.38	12.6				63.7	26.7	0.2	1.8	4.0	3.6	0.0	446
23.00	49.1	25.1	25.8	51.8	25.6	22.6	2.65	10.2				67.2	22.9	0.0	3.1	5.0	2.3	0.0	262
24.00								10.7				58.6	25.4	0.0	4.1	11.3	0.9	0.0	319
25.00	52.4	23.4	24.2	55.3	22.2	22.5	4.52	10.6				73.1	19.6	0.0	1.2	5.0	1.2	0.0	260
26.00								10.6				59.5	32.1	0.0	3.8	2.3	2.3	0.0	262
27.00	47.9	23.4	28.7	51.0	23.1	25.9	2.70	10.3				59.0	29.5	0.3	3.1	4.9	2.8	0.3	390
28.00								9.9				59.0	29.7	0.0	3.5	4.5	2.6	0.5	424
29.00	48.8	25.8	25.4	52.2	24.7	23.1	3.04	11.1				58.0	31.7	0.0	2.9	5.1	1.9	0.3	312
30.00								9.8				62.3	27.9	0.3	2.7	5.3	1.2	0.3	337
31.00	47.6	25.3	27.1	50.5	25.0	24.5	2.68	10.3				59.6	28.2	0.3	4.9	4.5	1.7	0.3	287
32.00								10.3				61.0	26.9	0.0	5.1	3.7	3.3	0.0	510
33.00	46.9	23.7	29.4	49.6	23.4	27.0	2.81	10.5				67.5	22.2	0.0	2.2	3.9	4.2	0.0	360
34.00								11.7				73.0	18.6	0.4	3.6	2.2	2.2	0.0	274
35.00	32.8	34.1	33.1	35.8	33.9	30.2	1.51	12.4				68.2	23.0	1.9	1.1	4.2	1.1	0.4	261
36.00								11.5				63.8	27.8	1.0	2.2	3.1	1.9	0.2	414
37.00	42.4	22.2	35.4	45.1	22.2	32.7	2.10	12.6				65.5	25.2	1.5	2.7	3.6	0.9	0.3	330
38.00								11.3				60.7	29.0	0.4	3.1	3.4	3.4	0.4	262
39.00	40.4	24.6	35.0	43.2	24.5	32.2	1.90	15.8				64.2	29.4	0.0	1.0	3.2	1.3	1.0	310
40.00								11.4				70.7	18.8	0.8	3.4	6.0	0.4	0.0	266
41.00	40.9	25.7	33.5	43.8	25.1	31.1	2.06	14.8				65.3	27.2	0.3	1.9	3.4	1.9	0.0	323
42.00	43.0	23.4	33.6	45.7	23.2	31.1	3.43	11.7				62.3	27.5	0.0	1.4	4.3	0.7	0.0	276

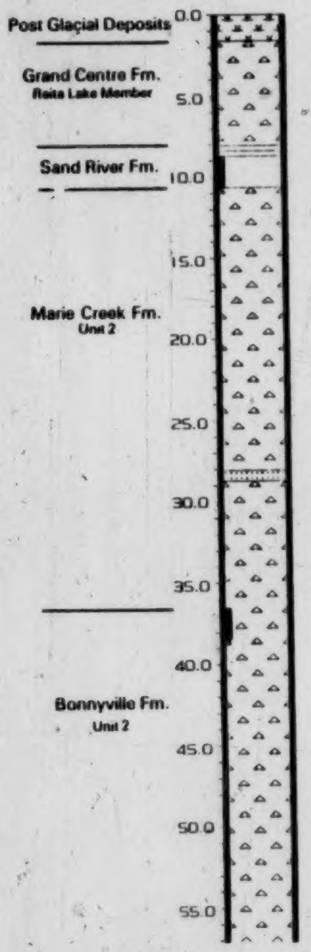
77 SR 35



Alberta Geological Survey Testhole 77 SR 35
Location of LSD 2 Sec 6 Twp 66 Rng 1 W of 4 Mer . NTS 73L
Elevation 2000 Ft 610 M Source 1:50,000 NTS 73L/10
Date drilled 197802 20 Logged by ANDRIASHEK

	TEXTURE (%)								MATRIX CARBONATE				COARSE SAND LITHOLOGY (%)						
DEPTH (M)	SAND -62	SILT 5um	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	CO2 (cc)	CO3 (%)	CA/MG	IGN MTM	QTZ	QTZT USS	LST	DST	LOC	DTM	N
2.50	41.0	20.8	38.2	43.8	24.0	32.2	1.42	10.2	3.8	1.6	0.77	68.4	29.2	2.4	0.0	0.0	0.3	0.0	804
3.00	41.8	22.5	35.7	45.5	23.6	30.9	1.61	11.0	3.5	1.5	1.21	69.0	27.6	3.1	0.0	0.0	0.4	0.0	673
4.00	38.6	26.7	34.7	42.2	28.8	29.0	1.48	11.8	20.2	8.4	0.25	68.4	27.5	1.4	0.6	1.6	0.5	0.0	702
5.00	42.3	22.3	35.4	45.9	24.0	30.1	1.64	11.9				67.3	27.8	2.4	0.4	1.3	0.7	0.0	745
6.00								12.4											
7.00								17.5											
8.00								16.3											
11.00								21.7											
12.00								21.5											
13.00								19.9											
14.00								14.1				74.5	21.7	1.2	1.7	0.7	0.2	0.0	419
15.00	42.1	25.1	32.8	45.6	27.4	27.0	1.81	11.3	24.1	10.1	0.26	71.6	22.9	2.1	1.1	2.0	0.2	0.0	933
16.00	40.7	26.0	33.3	44.5	28.1	27.4	1.77	11.6	24.1	10.1	0.21	67.0	26.3	2.7	1.2	2.5	0.6	0.0	1072
17.00	43.3	24.9	31.8	46.9	26.2	26.9	1.93	11.3	24.7	10.3	0.18	65.7	29.5	1.4	2.2	1.1	0.0	0.0	271
20.00	36.8	27.1	36.1	40.6	30.1	29.3	1.65	12.9	23.4	9.8	0.17	68.6	25.8	1.5	1.8	2.0	0.3	0.0	850
21.00	37.2	27.2	35.6	40.8	29.3	29.8	1.86	12.8	25.0	10.4	0.15	72.5	23.1	0.8	2.0	1.6	0.0	0.0	247
22.00	36.7	27.5	35.8	40.6	29.6	29.8	1.74	12.2	24.4	10.1	0.16	67.1	28.6	1.7	0.6	2.8	0.4	0.0	821
23.00																			
24.00	23.9	28.6	47.4	27.1	33.8	39.1	0.88	11.1	24.2	10.0	0.08	66.1	26.8	1.6	1.5	4.0	0.4	0.0	684
25.00	30.8	28.7	40.5	34.6	31.8	33.6	1.21	15.8	24.5	10.2	0.14	68.2	18.8	0.5	1.9	10.2	0.4	0.0	431
27.00								18.0											
28.00	43.4	26.7	29.9	46.8	28.3	24.9	3.56	9.9	37.2	15.4	0.14	70.8	25.3	0.6	1.3	2.6	1.2	0.0	154
29.00	42.2	27.8	30.0	46.0	29.5	24.5	3.27	11.7	34.4	14.3	0.14	65.9	22.8	0.8	3.3	8.5	1.3	0.0	399
30.00	43.4	25.6	30.9	46.9	28.6	24.5	2.91	9.8	37.9	15.9	0.26	64.0	21.0	0.8	3.5	10.0	1.1	0.0	400
31.00	41.6	29.1	29.3	45.0	32.5	22.5	3.07	9.8				65.8	16.8	0.5	2.8	12.9	1.8	0.0	398
32.00	41.5	28.0	30.5	45.1	30.9	24.0	2.82	10.2	36.3	15.1	0.16	62.0	22.3	1.3	1.3	11.8	1.6	0.0	382
33.50	41.6	28.4	30.0	45.1	31.3	23.7	2.83	10.1	35.2	14.7	0.20	65.1	17.0	1.1	2.7	12.1	1.3	0.0	364
34.00	41.2	28.2	30.6	44.8	30.8	24.4	2.51	9.4	39.9	16.6	0.18	63.0	19.0	1.5	3.6	12.3	0.6	0.0	332
35.00	42.4	27.7	29.9	45.9	30.4	23.7	2.94	10.5	35.8	14.9	0.21	59.6	18.5	1.6	2.6	16.5	1.3	0.0	389
36.00	41.8	29.7	28.5	45.7	31.9	22.5	2.79	10.2	38.8	16.2	0.24	60.6	25.7	2.0	1.7	8.9	0.8	0.0	368
37.00	39.4	27.9	32.7	43.1	31.0	25.9	2.93	10.7	28.1	11.8	0.28	60.3	27.4	1.5	4.7	3.9	1.9	0.0	383
38.00	37.2	27.9	34.9	40.3	32.3	27.4	2.61	9.8	35.7	14.9	0.23	57.6	33.6	0.6	3.2	3.2	[illegible]	0.0	342
39.50	36.7	26.2	37.0	39.8	32.1	28.1	2.67		27.7	11.6	0.38	56.9	29.6	2.0	6.3	3.7	1.7	0.0	348
41.00	48.8	24.0	27.2	52.4	28.0	19.7	3.47	8.6	29.6	12.4	0.27	66.3	23.8	1.4	4.4	3.5	1.1	0.0	433
41.50	48.0	25.2	26.7	51.8	27.0	21.2	4.24		31.5	13.2	0.36	77.9	16.7	0.4	3.3	1.5	0.2	0.0	538
43.00	48.5	24.0	27.5	52.0	26.3	21.7	2.71	8.5	23.0	9.7	0.41	63.8	26.7	0.9	4.2	2.8	1.7	0.0	356
44.00	47.8	24.6	27.6	51.6	27.4	21.0	2.31		22.3	9.4	0.28	68.6	24.5	1.0	2.0	3.9	0.0	0.0	306
46.00	44.7	25.1	30.1	48.3	29.4	22.3	2.59	8.8	24.9	10.5	0.45	57.1	33.7	0.9	2.3	2.9	3.2	0.0	350
52.00	40.1	29.2	30.6	43.9	33.2	22.9	2.56					59.1	27.6	0.9	3.9	5.8	2.9	0.0	362

77 SR 36



Alberta Geological Survey Testhole 77 SR 36
Location of LSD 9 Sec 24 Twp 66 Rng 4 W of 4 Mer . NTS 73L
Elevation 2090 Ft 637 M Source 1 50,000 NTS 73L/9
Date drilled 197802 21 Logged by ANDRIASHEK

DEPTH (M)	TEXTURE (%) SAND -62 5um	SILT	CLAY <4um	SAND >50um	SILT	CLAY <2um	VC SD 1 2mm	H2O (%)	MATRIX CARBONATE CO2 (cc)	CO3 (%)	CA/DO	IGN METM	COARSE SAND LITHOLOGY (%) QTZ	QTZT USS	LST	DST	LOC	OTH	N
2.00	43.4	24.9	31.8	46.6	26.0	27.4	1.46		28.4	12.0	0.37	64.2	21.6	0.5	2.6	4.2	1.0	0.0	190
3.00	41.5	27.5	31.0	45.2	27.5	27.3	1.35		26.3	11.0	0.30	57.8	27.1	3.0	6.0	6.0	0.0	0.0	166
4.00	41.7	26.5	31.8	45.0	27.7	27.3	1.30	12.7	24.9	10.4	0.31	62.3	24.6	4.2	3.9	4.4	0.7	0.0	594
5.00	41.7	25.6	32.7	45.1	26.7	28.2	1.26	12.2	25.7	10.7	0.19	62.0	23.2	4.0	4.6	5.1	1.0	0.0	648
6.00	40.6	25.1	34.3	43.8	26.7	29.6	1.91	12.2	27.4	11.4	0.21	68.5	24.4	3.8	0.9	2.1	0.2	0.0	422
7.00	42.4	24.5	33.0	45.9	25.6	28.5	1.86	12.3	24.8	10.3	0.17	67.4	24.7	3.3	1.6	2.3	0.6	0.0	430
8.00	40.5	24.9	34.7	43.5	26.4	30.1	2.15	13.3	23.6	9.8	0.14	66.6	25.5	2.0	2.3	2.5	0.8	0.0	608
8.50								20.6											
10.00																			
11.00	40.7	29.9	29.4	44.4	30.3	25.3	2.89	11.4	35.1	14.6	0.13	63.1	18.3	1.1	4.4	12.8	0.3	0.0	360
12.00	42.2	29.1	28.7	45.9	29.4	24.7	3.41	11.2	38.5	16.1	0.23	60.4	19.8	0.2	2.5	15.8	0.9	0.0	404
13.00	44.7	29.6	25.6	48.5	30.5	21.0	3.01	9.8	35.1	14.6	0.17	65.6	19.2	1.0	3.3	9.2	1.3	0.0	390
14.00	45.1	28.7	26.2	48.8	29.4	21.9	2.55	10.5	35.5	14.9	0.30	65.3	21.0	1.2	4.0	6.8	1.5	0.0	352
15.00	51.8	25.1	23.1	55.7	25.5	18.9	4.42	10.0	31.4	13.2	0.32	63.6	24.7	0.6	3.1	6.8	1.3	0.0	353
16.00	46.7	26.2	27.1	50.3	28.2	21.5	2.93	8.9	30.7	12.9	0.33	67.3	22.0	0.8	3.5	4.0	2.4	0.0	373
17.00	47.0	27.5	25.4	50.9	29.0	20.2	3.99	9.9	33.8	14.1	0.17	68.7	20.9	0.2	4.1	4.7	1.4	0.0	492
18.00	46.1	27.6	26.3	49.9	28.5	21.6	3.38	9.6	29.6	12.4	0.33	60.0	27.5	1.7	4.7	3.7	1.9	0.0	407
19.00	46.0	26.8	27.2	49.9	30.7	19.4	3.16	10.0	29.4	12.3	0.29	69.1	20.2	1.5	1.9	4.6	2.6	0.0	411
20.00	46.3	27.2	26.5	49.9	30.4	19.7	3.28	10.0	30.2	12.7	0.40	66.0	21.7	1.2	4.3	3.4	2.3	0.0	415
21.00	45.4	27.5	27.1	49.3	31.2	19.5	3.01	10.3	29.1	12.2	0.31	66.4	20.7	1.1	4.2	5.8	1.6	0.0	381
22.00	45.3	26.6	28.0	49.0	31.3	19.7	2.90	10.0	28.8	12.1	0.30	65.5	21.5	0.6	5.4	4.8	2.0	0.0	354
23.00	44.2	26.8	28.9	48.1	31.1	20.8	3.00	10.8	28.4	11.9	0.31	72.9	17.5	0.6	1.9	4.7	2.1	0.0	365
24.00	42.8	27.0	30.2	46.3	30.9	22.8	2.50	11.0	29.4	12.3	0.37	64.2	24.1	0.9	5.4	3.0	2.1	0.0	332
25.00	42.2	27.6	30.2	46.0	31.7	22.2	2.88	10.7	28.0	11.7	0.25	69.8	19.4	0.6	5.4	3.8	0.5	0.0	371
26.00	41.9	27.7	30.4	45.7	31.7	22.7	2.63	10.9	29.4	12.4	0.31	63.5	26.7	0.9	2.0	2.9	3.5	0.0	348
27.00	40.7	29.9	29.5	44.6	33.7	21.7	2.49	11.2	29.5	12.4	0.26	64.6	24.6	0.9	4.4	4.4	1.2	0.0	342
29.00	50.1	28.4	21.5	54.6	30.0	15.4	2.94	10.2	31.2	12.1	0.35	69.6	18.5	1.4	2.7	4.8	2.5	0.0	372
31.00	49.2	28.1	22.6	53.8	29.7	16.6	3.21	10.1	29.4	12.3	0.31	68.1	21.3	0.5	4.2	4.2	1.1	0.0	427
32.00	50.2	27.6	22.2	54.7	29.4	16.0	3.48	10.0	31.6	13.3	0.41	66.7	21.8	0.2	4.3	5.0	1.9	0.0	417
33.50	48.6	29.1	22.3	53.2	31.1	15.7	3.23	9.5	28.1	11.8	0.42	67.0	17.7	1.4	5.7	5.9	1.4	0.0	406
34.00	50.2	28.0	21.8	54.6	30.0	15.4	3.29	10.7	38.9	16.2	0.24	63.6	25.7	0.0	2.2	6.0	2.4	0.0	401
35.00	51.9	27.9	20.1	56.7	28.7	14.6	3.60	10.5	37.2	15.5	0.21	65.3	22.1	1.1	5.1	4.2	1.8	0.0	452
36.00	39.6	27.9	32.5	43.2	27.6	29.2	2.42	10.7	11.0	4.7	0.81	58.1	34.7	1.9	3.1	0.9	0.6	0.0	320
37.00	42.0	27.6	30.4	45.5	27.5	27.0	2.16	9.9	11.6	4.9	0.71	62.2	32.4	0.6	3.7	0.3	0.3	0.0	296
38.00	41.4	28.8	29.8	45.0	31.0	24.0	2.22	9.6	14.0	5.9	0.58	63.2	30.0	1.6	2.6	1.0	1.3	0.0	313
39.50	44.1	28.2	27.8	47.6	30.3	22.1	2.26	9.6	12.1	5.1	0.67	62.9	31.6	0.3	1.3	1.3	2.6	0.0	310
41.00	44.5	30.1	25.4	48.4	31.9	19.7	2.25	10.3	13.7	5.8	0.73	64.7	28.2	1.8	1.8	2.1	0.9	0.0	326
41.50	44.3	26.2	29.6	47.8	28.9	23.3	2.21	10.0	13.4	5.7	0.75	63.5	33.4	2.0	0.7	0.0	0.3	0.0	293
43.00	47.8	29.4	22.8	51.5	31.2	17.3	2.46	10.8	12.0	5.1	0.50	58.1	34.4	1.2	1.7	3.4	1.2	0.0	349
44.00	49.4	25.1	25.5	53.2	27.0	19.8	2.75	10.1	12.0	5.1	0.34	59.4	33.0	1.8	1.5	1.8	2.4	0.0	342
46.00	46.6	27.6	25.8	50.3	28.8	21.0	2.28	10.7	11.3	4.8	0.56	59.3	34.8	2.3	1.3	1.0	0.9	0.0	302
47.00	46.7	29.5	23.8	50.6	30.8	18.6	2.28	10.6	13.5	5.8	0.49	60.9	33.6	1.5	2.1	1.5	0.3	0.0	327
48.00	47.4	28.3	24.3	51.0	30.5	18.5	3.15	10.5	14.9	6.3	0.54	63.5	29.7	3.8	1.0	0.5	1.3	0.0	394
50.00	45.1	30.1	24.9	49.4	31.0	19.6	1.48	10.6	10.7	4.5	0.42	54.5	34.2	3.0	3.0	1.0	3.0	0.0	202
51.00	45.2	29.7	25.1	49.2	31.2	19.6	1.75	10.9	10.6	4.5	0.44	55.1	38.8	3.3	0.6	0.6	0.6	0.0	178
52.00	45.9	29.6	24.5	50.1	31.[illegible]	18.3	1.56		11.8	5.0	0.46	47.5	44.4	2.2	0.4	1.3	3.1	0.0	223
53.00	45.7	29.5	24.8	49.6	31.6	18.8	1.52	11.2	10.6	4.5	0.58	54.3	38.0	1.9	1.4	1.0	3.4	0.0	208
54.00	48.9	29.3	21.8	53.1	30.5	16.4	1.39	10.7	9.6	4.1	0.39	46.7	46.2	3.5	0.5	0.0	2.5	0.0	199
55.00	46.4	28.5	25.1	50.2	30.0	19.8	1.47		11.0	4.6	0.46	51.8	39.6	3.5	1.5	1.5	2.0	0.0	197
57.00	48.2	30.1	21.7	52.5	30.9	16.6	1.16					46.5	45.5	3.2	1.1	1.1	2.2	0.0	187

B. Appendix B: Clay mineralogy of representative samples from till formations, Sand River map area

Formation	Testhole	Location LSD-Sec-Tp-Rg-W4M	Depth (m)	Illite %	Kaolinite %	Montmorillonite %	Chlorite %
Grand Centre Fm. Vilna Member	77SR-8	11-25-61-1-W4M	8	53	19	18	10
			16	53	19	18	10
			22	51	25	16	7
Kehiwin Lake Member	77SR-17	15-9-61-8-W4M	4	58	22	15	5
Reita Lake Member	T-3	8-36-61-1-W4M	2	56	23	15	6
			6	60	18	15	6
	T-6	15-31-62-3-W4M	2.5	60	20	10	10
			5	56	15	20	10
	T-14	4-17-60-3-W4M	2	50	25	19	6
	T-41	3-29-58-3-W4M	3	55	20	21	5
			6	58	23	16	3
	T-44	14-24-61-6-W4M	7	58	19	18	5
			9	50	28	15	8
			10	54	25	17	4
	77SR-17	15-9-61-8-W4M	14	57	23	14	6
	77SR-36	9-24-66-4-W4M	3	56	25	15	3
			7	53	26	14	7
Hilda Lake Member	T-18	9-18-61-3-W4M	3	55	20	20	5
			6	45	10	35	10
	T-42	13-5-65-3-W4M	17	51	24	17	7
Marie Creek Fm. Unit 1	T-3	8-36-61-1-W4M	45	40	30	25	5
			48	45	25	24	6
	77SR-8	11-25-61-11-W4M	46	55	23	15	7
			55	50	24	19	7
	77SR-17	15-9-61-8-W4M	31	53	24	16	7
Marie Creek Fm. Unit 2	T-3	8-36-61-1-W4M	13	58	23	15	4
			17	58	21	16	4
	T-6	15-31-62-3-W4M	8	55	20	20	5
			12	55	15	20	10
	T-14	4-17-60-3-W4M	17	54	24	17	5
			24	54	25	15	7
			31	56	25	13	7
	T-18	9-18-61-3-W4M	17	55	25	15	5
			27	50	25	15	10
	T-41	3-29-58-3-W4M	8	63	20	13	4
			24	51	27	15	7
	T-42	13-5-65-3-W4M	28	56	26	13	5
			37	58	23	13	6
	T-44	14-24-61-6-W4M	17	54	25	21	0
			24	56	27	14	3
	77SR-8	11-25-61-11-W4M	33	56	19	18	7
	77SR-17	15-9-61-8-W4M	26	63	20	13	4
			29	58	23	14	4
			32	53	24	16	7
	77SR-36	9-24-66-4-W4M	11	57	26	11	6
			21	48	25	19	8
			32	48	26	22	5
			34	51	21	21	7
Bonnyville Fm. Unit 2	T-6	15-31-62-3-W4M	36	45	25	25	5
			40	40	30	25	5
	T-18	9-18-61-3-W4M	34	45	20	25	10
			37	45	25	20	10
	T-41	3-29-58-3-W4M	37	45	41	9	5
			46	52	25	17	6
	77SR-28	10-22-69-11-W4M	19	56	21	19	3
			29	47	21	25	8
			49	50	22	20	8
	77SR-36	9-24-66-4-W4M	46	49	25	22	4

C. Appendix C: Variations with depth in the composition of the very coarse sand fraction

A common method of characterizing, differentiating and correlating till units is by comparing the percentage of mineral or rock types in a till unit at a given site, with those rock types from samples of what is considered to be the same unit at other sites. While this technique may be appropriate in many cases, it has limited application in those areas where the rock types from the source area have either been diluted by locally derived rocks, or, where changing glacial processes have preferentially eroded or removed a particular rock or mineral group from the given size fraction studied (Shetsen, 1984). In either of these cases, negative dependent relationships with the remaining rock types will result.

In order to determine if the observed variations within a till unit are a result of either preferential erosion or, a change in the source area, it is necessary to firstly eliminate the effects of either dilution or erosion, so that the inherent characteristics of the till can be examined. To do this, the percentage of each rock type are recalculated, excluding those rock type or types that are deemed to be locally derived and which are not representative of the rocks from the glacial source area. This procedure is referred to as "normalizing the data" and it enables a more clear understanding of the behavior of the rock groups in response to the removal or addition of other rocks (Shetsen, 1984).

Comparisons of the variations in the composition of the very coarse sand fraction of all the tills show that for each till unit certain rock types display inverse dependent relationships. That is, an increase in the percentage of one rock type is matched by a corresponding decrease in another rock type. For example, tills of the Grand Centre Formation are characterized by a higher ratio of igneous and metamorphic fragments to carbonate and quartz fragments, compared to that ratio of the tills in either the Marie Creek or Bonnyville Formations. The Marie Creek till, on the other hand, is characterized by a higher ratio of carbonate fragments to quartz, compared to that ratio of the tills in either the Grand Centre or Bonnyville Formations. Finally, the Bonnyville till is characterized by a higher ratio of quartz fragments to igneous and metamorphic rock fragments, compared to that ratio of the tills of either the Grand Centre or Marie Creek Formations.

In the case of the Marie Creek Formation, the ratio of carbonates to quartz fragments is characteristically very high at the top of the formation, but becomes either gradationally or abruptly lower with depth (Appendix A and Table 6). When using percentages, it may appear that quartz is being added preferentially and is diluting the amount of carbonates with depth. This is because the total amount of quartz is greater than the amount of carbonate rocks in any given sample, and consequently a change in the amount of quartz affects the resulting percentage of carbonate rocks more so than the reverse. However, this decrease in the ratio of carbonates to quartz with depth can result from any one of the following possibilites:

3. a significant decrease in the amount of carbonates, with the amount of quartz remaining constant (in which case, the percent of all other rock types should increase as well as that of quartz),
4. a significant increase in the amount of quartz, with the amount of carbonates remaining constant (in which case the percentage of all other rock types should show a decrease), or
5. a complex relationship in which the amount of carbonates actually decrease and the amount of quartz actually increases the combination of which would result in a lower carbonate to quartz ratio, but the precentage of the remaining rock types would neither increase nor decrease.

To determine the nature of this decrease in the ratio of carbonates to quartz with depth in the Marie Creek Formation, it is necessary to first normalize the percentage of carbonate rocks with respect to quartz (ie. the percent of carbonate rocks is recalculated excluding quartz from the total) and to secondly normalize the percentage of quartz with respect to carbonate rocks (ie. the percent of quartz is recalculated, excluding carbonate rocks from the total). This serves to divorce the dependency between carbonate and quartz, and allows each to be separately compared to the remaining rock types. In doing so, the apparent increase (or decrease) of a given rock type can be determined to be real or not. The results of that comparison of the normalized values in the Marie Creek Formation indicate that a complex relationship exists: carbonate fragments actually decrease with depth and conversely quartz fragments actually increase with depth (Figure 61).

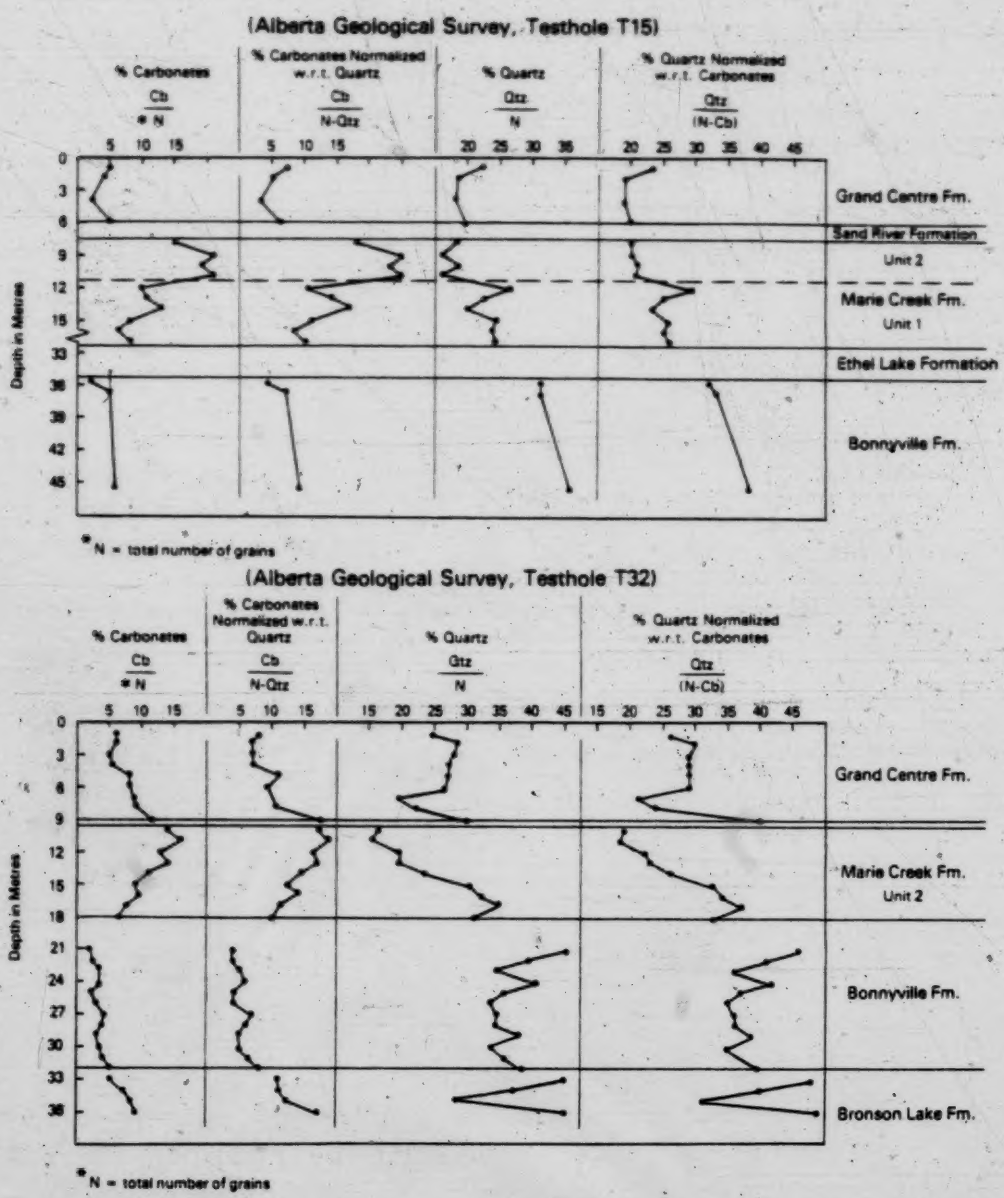


Figure: 61 Variations with depth in the mineralogy of the very coarse sand fraction of the Marie Creek Formation. The figure compares the normalized and non-normalized percentages of carbonate and quartz rock fragments, and shows both a real decrease in the amount of carbonate and a real increase in the amount of quartz with depth in the Marie Creek Formation.

In some testholes this decrease in the carbonate to quartz ratio with depth is not gradual but, rather abrupt. Furthermore, the abrupt change occurrs at the same depth where changes in other properties, such as texture, also are evident. For example, in testhole T-15 (Appendix A) the amount of quartz in the Marie Creek Formation increases abruptly at the top of the underlying clayey till of unit 1. Unit 1 is considered to represent basal erosional facies of the Marie Creek Formation, as evidenced by the incorporation of silt and clay "clasts" of the underlying of the Ethel Lake Formation in the till. It seems likely therefore, that the increase of quartz and decrease of carbonates near the base of the Marie Creek Formation can be attributed in most places to the erosion and incorporation of the underlying quartz rich, carbonate poor till of the Bonnyville Formation.

D. Appendix D: Description of field observations, and laboratory procedures.

Field Observations

Listed below are most of the observations typically recorded in the field. These include observations from both outcrops and dry-auger flite samples.

1. Color - Color is recorded for both oxidized and unoxidized portions of outcrop and testhole samples. Generally the oxidized colors of outcrops are recorded from the weathered, surface material. Colors of the units are compared to the Munsell Soil Color Chart.
2. Texture - A field estimate is made of the matrix texture (e.g. claey-sand till). Related to the texture is the moisture content, expressed as dry, moist, or wet, which affects the ease of digging or drilling.
3. Pebble lithology - Only the significant changes in the pebble lithology were recorded. Drill samples commonly do not contain sufficient pebbles for easy counts.
4. Joint and fracture density - Joint and fracture planes are recorded from outcrops only. The density of the fractures, their shape, size, and presence of secondary mineralization along the surfaces were noted.
5. Stratification, laminations, partings - These structural elements were recorded for both outcrops and dry-auger flite samples. Bedding and partings are visible in drill samples even though they are twisted and distorted by the drilling process.
6. Inclusions of glacially displaced sediment - Masses of glacially displaced and transported older sediment are more easily recorded in outcrops, but can also be recognized in dry-auger flite samples if the displaced material is lithologically distinct from the host material.
7. Boulder concentrations - Boulder concentrations are observed primarily in outcrops though, if the concentration is dense, it may be encountered in drilling.
8. Pebble orientations (in till) - In this study pebble fabrics were measured in only one outcrop.
9. Nature of contacts - The nature of the contact between units is recorded in both outcrop and dry-auger flite descriptions.

Laboratory Procedures

The stages from sample collection to computer generated data plots are depicted in Figure 62.

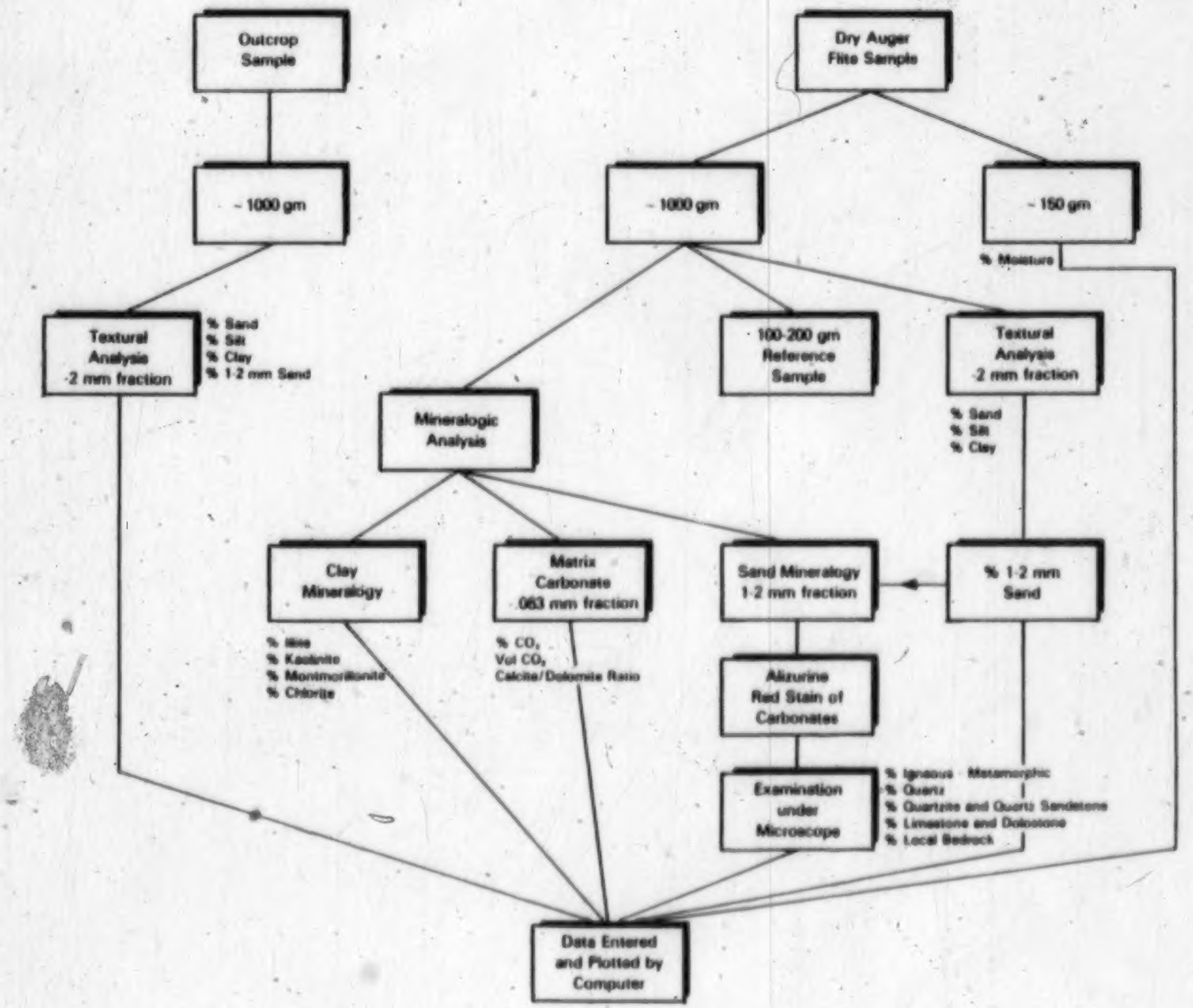
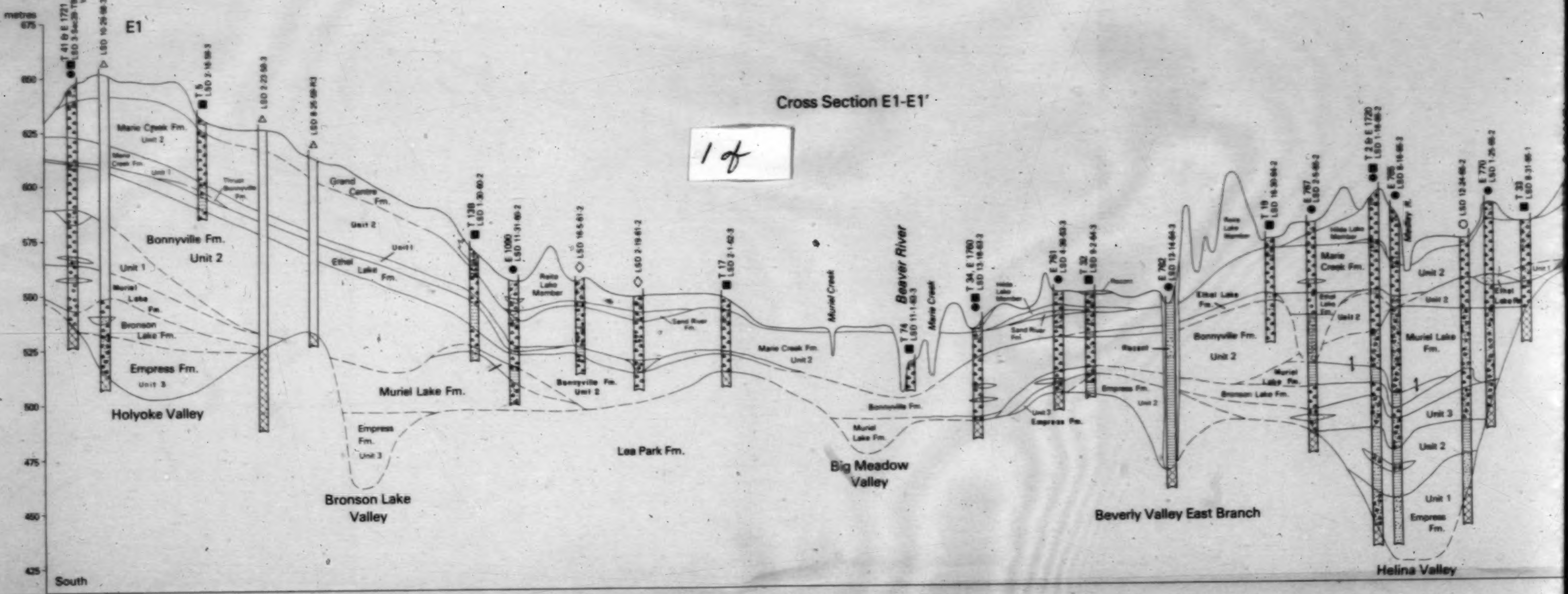
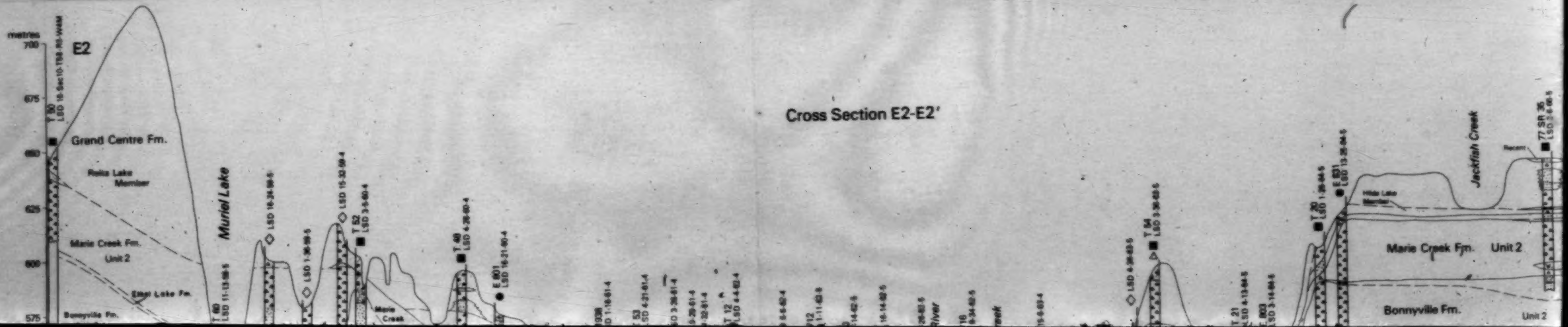

Outcrop Sample
~1000 gm
Textural Analysis -2 mm fraction
% Sand
% Silt
% Clay
% 1-2 mm Sand
Dry Auger Flite Sample
~1000 gm
~150 gm
% Moisture
100-200 gm Reference Sample
Textural Analysis -2 mm fraction
% Sand
% Silt
% Clay
Mineralogic Analysis
Clay Mineralogy
% Illite
% Kaolinite
% Montmorillonite
% Chlorite
Matrix Carbonate .063 mm fraction
% CO₂
Vol CO₂
Calcite/Dolomite Ratio
Sand Mineralogy 1-2 mm fraction
% 1-2 mm Sand
Alizurine Red Stain of Carbonates
Examination under Microscope
% Igneous - Metamorphic
% Quartz
% Quartzite and Quartz Sandstone
% Limestone and Dolostone
% Local Bedrock
Data Entered and Plotted by Computer

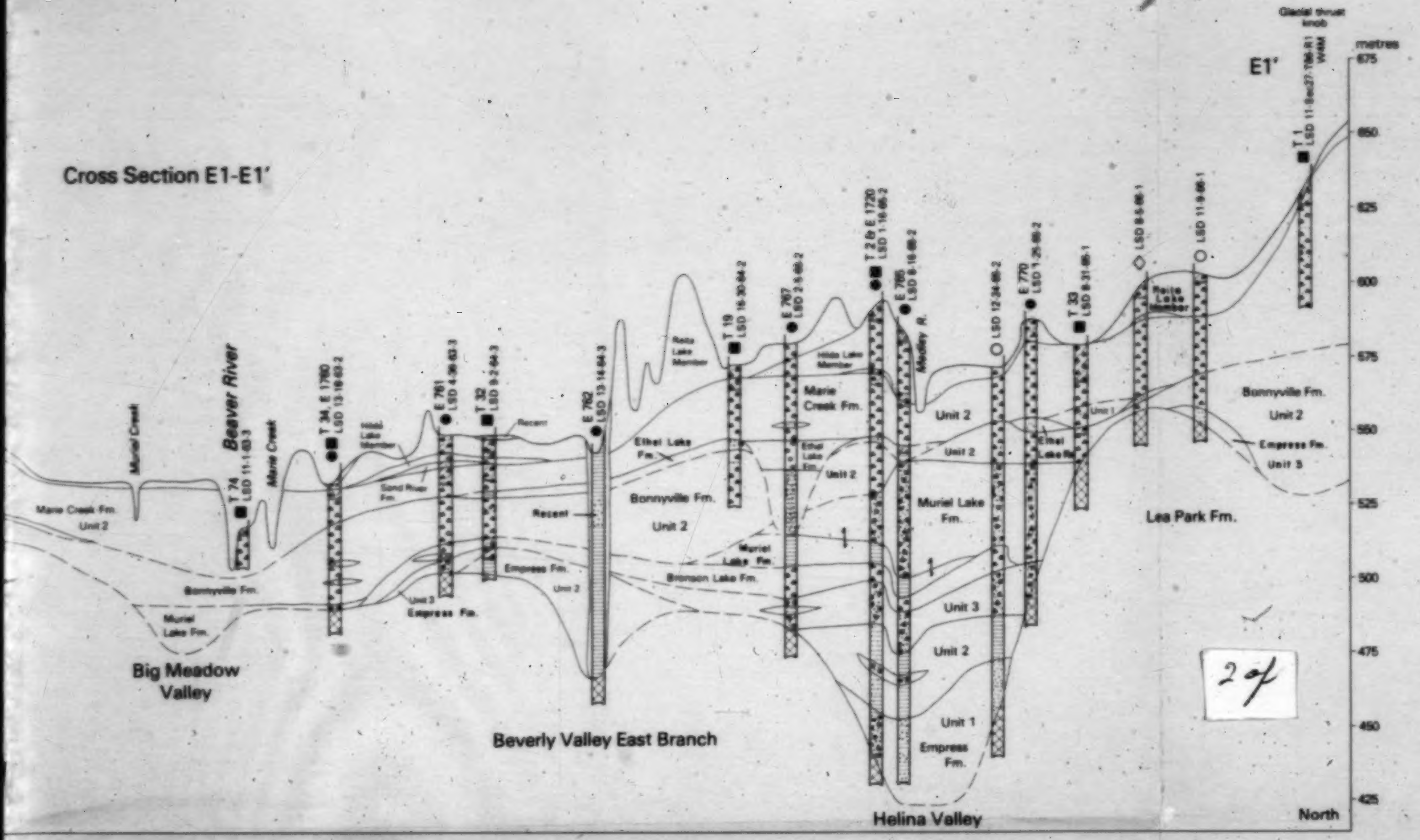
Figure 62 Flow chart depicting the stages of till sample analysis


Cross Section E1-E1'
E1
metres
675
650
625
600
575
550
525
500
475
450
425
South
T 41 & E 1721
LSD 3 Sec 28 T58 R3 W4M
LSD 10-26-58-3
T 6
LSD 2-16-59-3
LSD 2-23-59-3
LSD 8-25-59-R3
T 128
LSD 1-30-60-2
E 1090
LSD 11-31-60-2
LSD 16-5-61-2
LSD 2-19-61-2
T 17
LSD 2-1-62-3
T 74
LSD 11-1-63-3
T 34, E 1760
LSD 13-16-63-2
E 761
LSD 4-36-63-3
T 32
LSD 9-2-64-3
E 762
LSD 13-14-64-3
T 19
LSD 16-30-64-2
E 767
LSD 2-5-65-2
T 2 & E 1720
LSD 1-16-65-2
E 765
LSD 8-16-65-3
LSD 12-24-65-2
E 770
LSD 1-25-65-2
T 33
LSD 8-31-65-1
Marie Creek Fm.
Unit 2
Marie Creek Fm.
Unit 1
Thrust Bonnyville Fm.
Grand Centre Fm.
Unit 2
Unit 1
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
Unit 1
Muriel Lake Fm.
Bronson Lake Fm.
Empress Fm.
Unit 3
Holyoke Valley
Empress Fm.
Unit 3
Bronson Lake Valley
Muriel Lake Fm.
Reita Lake Member
Sand River Fm.
Bonnyville Fm.
Unit 2
Lea Park Fm.
Muriel Creek
Beaver River
Marie Creek
Marie Creek Fm.
Unit 2
Bonnyville Fm.
Muriel Lake Fm.
Big Meadow Valley
Reita Lake Member
Sand River Fm.
Recent
Unit 3
Empress Fm.
Empress Fm.
Unit 2
Reita Lake Member
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
Muriel Lake Fm.
Bronson Lake Fm.
Beverly Valley East Branch
Hilda Lake Member
Marie Creek Fm.
Ethel Lake Fm.
Unit 2
Medley R.
Unit 2
Unit 2
Muriel Lake Fm.
Unit 3
Unit 2
Unit 1
Empress Fm.
Ethel Lake Fm.
Unit 1
Helina Valley

1 of

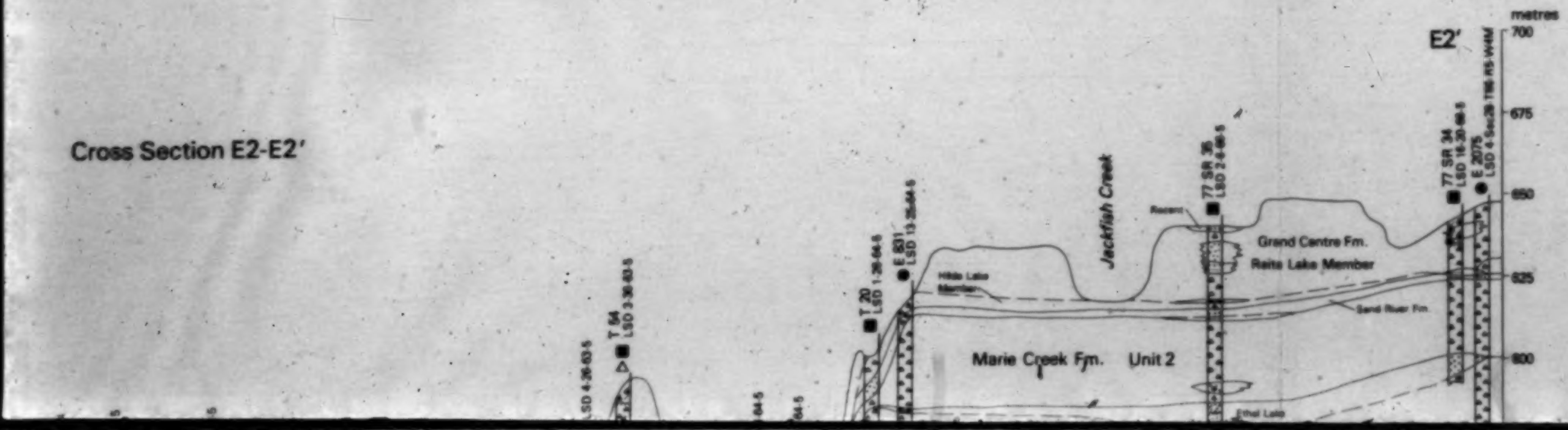

Cross Section E2-E2'
E2
metres
700
675
650
625
600
575
T 90
LSD 16-Sec10-T58-R5-W4M
Grand Centre Fm.
Reita Lake Member
Marie Creek Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Muriel Lake
LSD 11-13-59-5
LSD 16-34-58-5
LSD 1-36-59-5
LSD 15-32-59-4
T 52
LSD 3-5-60-4
Marie Creek
T 48
LSD 4-28-60-4
E 801
LSD 16-21-60-4
LSD 4-36-63-5
T 54
LSD 3-36-63-5
T 20
LSD 1-26-64-5
E 831
LSD 13-26-64-5
Hilda Lake Member
Jackfish Creek
Recent
T 7 SR 35
Marie Creek Fm.
Unit 2
Bonnyville Fm.
Unit 2

Cross Section E1-E1′


Glacial thrust knob
E1′
metres
675
650
625
600
575
550
525
500
475
450
425
T 1 LSD 11-Sec27 T66 R1 W4M
T 74 LSD 11-1-63-3
T 34, E 1780 LSD 13-18-63-2
E 781
T 32
E 782 LSD 13-14-64-3
T 19 LSD 16-30-64-2
E 787
T 2 & E 1720
E 785
E 770
T 33
Muriel Creek
Beaver River
Marie Creek
Marie Creek Fm. Unit 2
Bonnyville Fm.
Muriel Lake Fm.
Big Meadow Valley
Hilda Lake Member
Sand River Fm.
Unit 3 Empress Fm.
Recent
Empress Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
Muriel Lake Fm.
Bronson Lake Fm.
Beverly Valley East Branch
Reita Lake Member
Marie Creek Fm.
Hilda Lake Member
Ethel Lake Fm.
Unit 2
Medley R.
Unit 2
Muriel Lake Fm.
Unit 3
Unit 2
Unit 1
Empress Fm.
Helina Valley
Ethel Lake Fm.
Unit 1
Reita Lake Member
Lea Park Fm.
Bonnyville Fm.
Unit 2
Empress Fm.
Unit 3
North

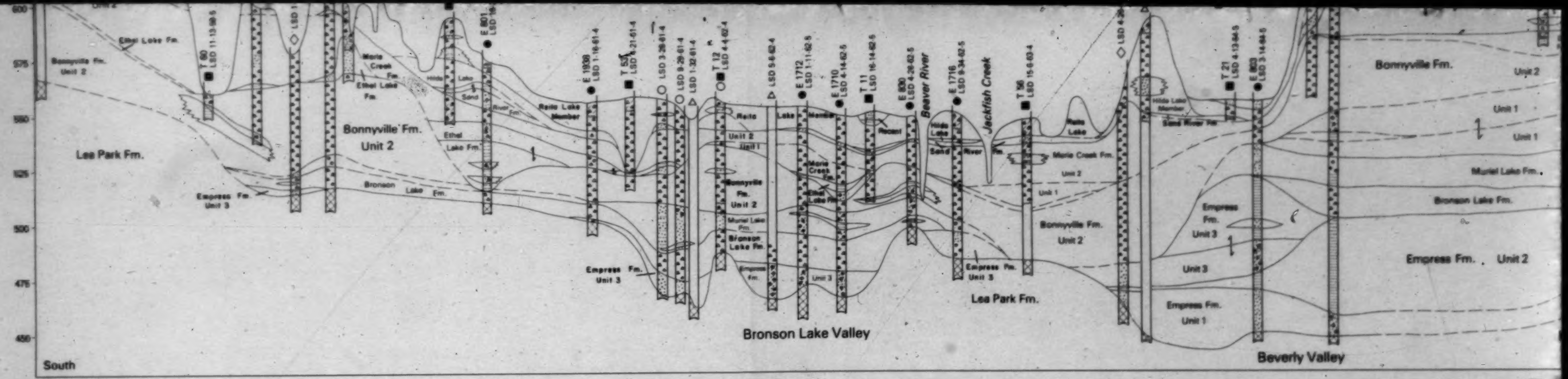
2 of

Cross Section E2-E2′


E2′
metres
700
675
650
625
600
T 54 LSD 3-35-63-5
T 20 LSD 1-26-64-5
E 831 LSD 13-25-64-5
Hilda Lake Member
Jackfish Creek
Recent
77 SR 36 LSD 2-8-65-5
Grand Centre Fm.
Reita Lake Member
Sand River Fm.
77 SR 34 LSD 16-20-66-5
E 2075 LSD 4-Sec28 T66 R5 W4M
Marie Creek Fm.
Unit 2
Ethel Lake

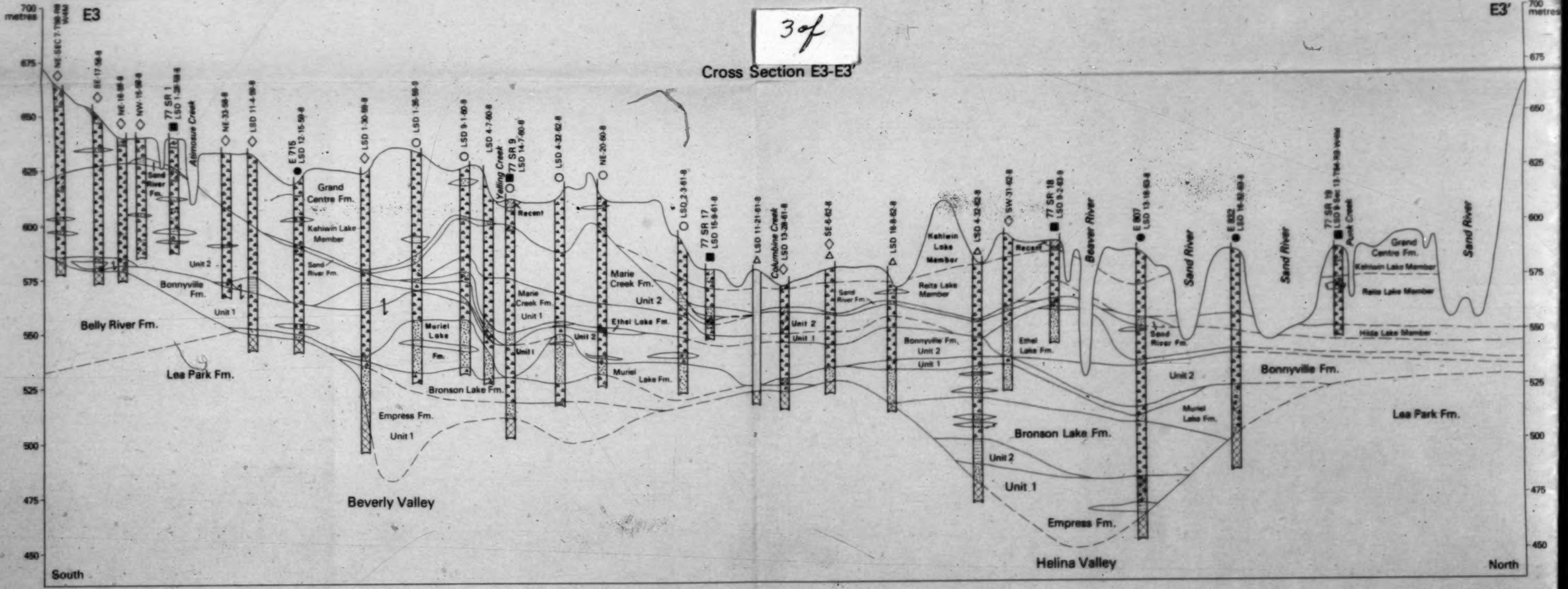
Quaternary Stratigraphy of the Sand River Map Area

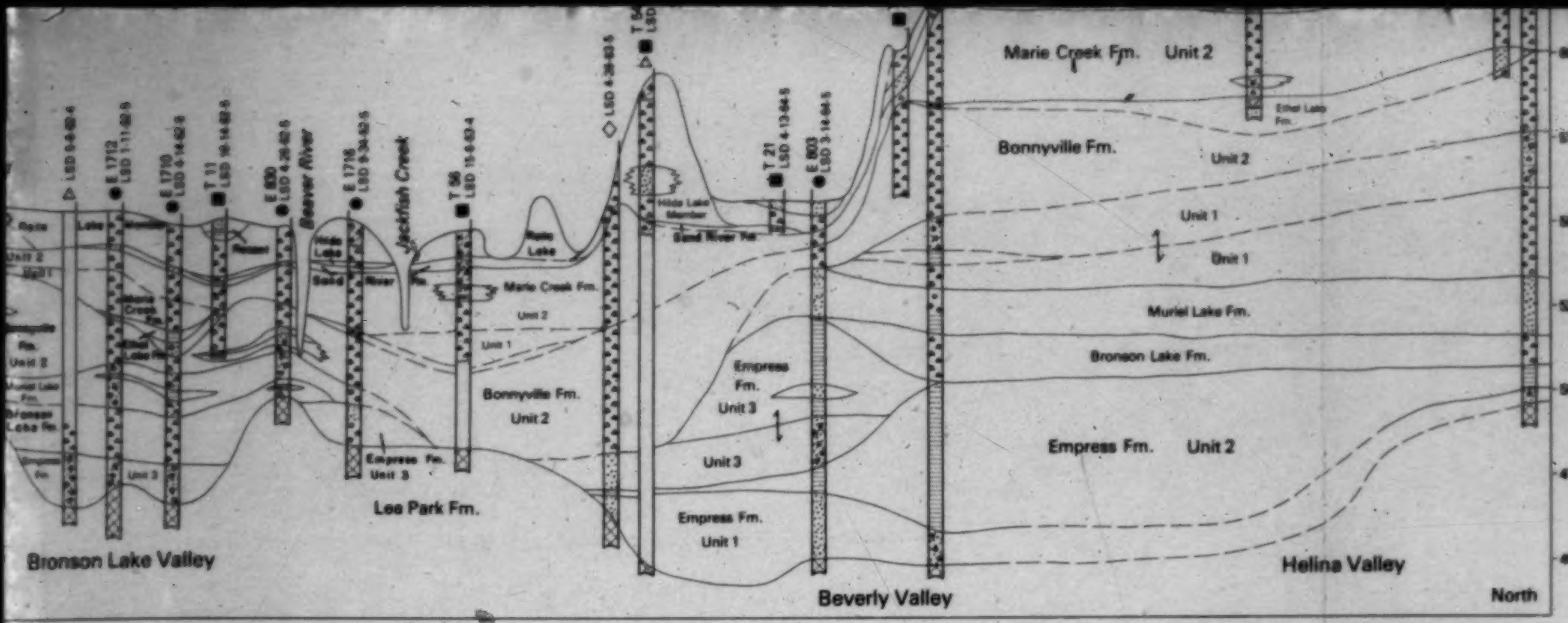
	QUATERNARY	
	HOLOCENE (RECENT)	
☐	**POST GLACIAL STRATIFIED DEPOSITS**	Clay, silt, sand, gravel; undifferentiated eolian, fluvial, and lacustrine deposits
	PLEISTOCENE	
	GRAND CENTRE FORMATION	
☐	**VILNA MEMBER**	Clayey diamicton; contains abundant blocks of glacially transported older sediment; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
☐	**KEHIWIN LAKE MEMBER**	Sandy diamicton; very coarse sand fraction is rich in igneous, metamorphic and quartz rock fragments; glacial sediment (till)
☐	**REITA LAKE MEMBER**	Clayey-sand diamicton; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
☐	**HILDA LAKE MEMBER**	Clayey diamicton; contains abundant blocks of glacially transported older sediment; very coarse sand fraction rich in igneous and metamorphic rock fragments; glacial sediment (till)
☐	**SAND RIVER FORMATION**	Sand and gravelly sand; minor silt and clay; glaciofluvial sediment
	MARIE CREEK FORMATION	
☐	**UNIT 2**	Sandy diamicton; very coarse sand fraction rich in carbonate rock fragments; glacial sediment (till)
☐	**UNIT 1**	Clayey diamicton; contains discrete lenses of bedded silt and clay; very coarse sand fraction rich in carbonate rock fragments; glacial sediment (till)
☐	**ETHEL LAKE FORMATION**	Silt and clay; minor sand and gravel; predominantly glaciolacustrine sediment
	BONNYVILLE FORMATION	
☐	**UNIT 2**	Diamicton; sandy in east two thirds of map area, clayey in west; very coarse sand fraction rich in quartz fragments; glacial sediment (till)
☐	**UNIT 1**	Clayey diamicton; recognized by very low resistivity response; glacial sediment (till) that is overlain by sand and gravel in some places
☐	**MURIEL LAKE FORMATION**	Sand and gravel; minor silt and clay; glaciofluvial sediment
☐	**BRONSON LAKE FORMATION**	Clayey diamicton and clay undivided; recognized primarily by very low resistivity response; very coarse sand fraction rich in quartz and shale bedrock fragments; mixed glacial sediment (till) and glaciolacustrine sediment
	EMPRESS FORMATION	
☐	**UNIT 3**	Sand and gravel; contains igneous and metamorphic clasts derived from the Canadian Shield; glaciofluvial sediment
☐	**UNIT 2**	Silt and clay; undivided fluvial and glaciolacustrine sediment
☐	**UNIT 1**	Sand and gravel; contains quartzite and chert clasts derived from the Cordillera; commonly referred to as preglacial Saskatchewan sand and gravel


600
575
550
525
500
475
450
South
Lea Park Fm.
Bonnyville Fm. Unit 2
Ethel Lake Fm.
Empress Fm. Unit 3
Bronson Lake Fm.
Marie Creek Fm.
Hilda Lake
Sand River Fm.
Reita Lake Member
Muriel Lake Fm.
Beaver River
Jackfish Creek
Unit 1
Unit 2
Unit 3
Empress Fm. Unit 1
Empress Fm. Unit 2
Bronson Lake Valley
Beverly Valley
T 50
E 801
E 1938
T 53
T 12
E 1712
E 1710
T 11
E 800
E 1716
T 56
T 21
E 803

3 of

Cross Section E3-E3'


700 metres
675
650
625
600
575
550
525
500
475
450
E3
E3'
South
North
Belly River Fm.
Lea Park Fm.
Bonnyville Fm.
Unit 1
Unit 2
Sand River Fm.
Atimoswe Creek
E 715
Grand Centre Fm.
Kehiwin Lake Member
Muriel Lake Fm.
Bronson Lake Fm.
Empress Fm. Unit 1
Beverly Valley
77 SR 1
77 SR 9
Yelling Creek
Recent
Marie Creek Fm.
Ethel Lake Fm.
77 SR 17
Columbine Creek
Reita Lake Member
77 SR 18
Beaver River
E 807
Sand River
E 802
77 SR 19
Punk Creek
Hilda Lake Member
Empress Fm.
Helina Valley

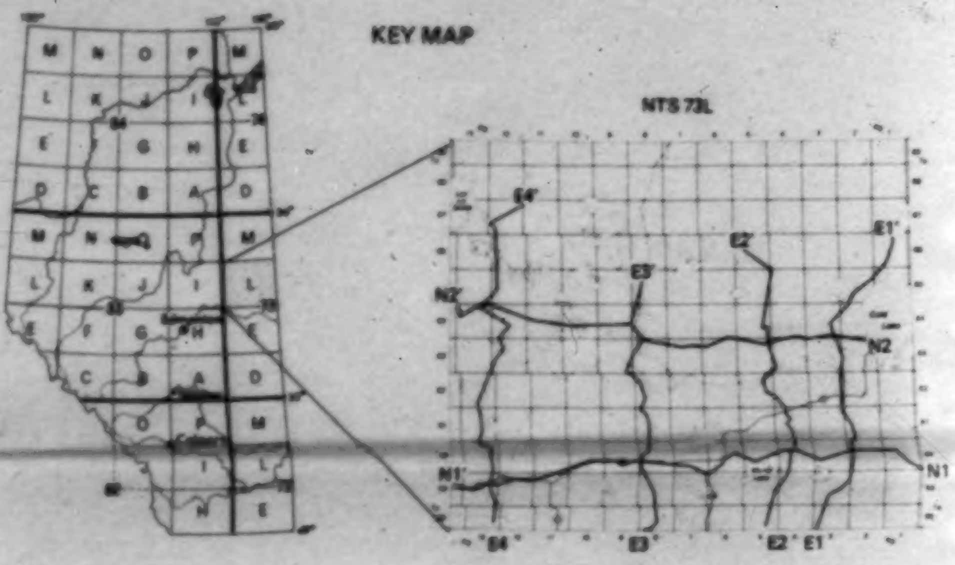

Marie Creek Fm.
Unit 2
Bonnyville Fm.
Unit 2
Unit 1
Unit 1
Muriel Lake Fm.
Bronson Lake Fm.
Empress Fm.
Unit 2
Empress Fm.
Unit 3
Unit 3
Empress Fm.
Unit 1
Bonnyville Fm.
Unit 2
Empress Fm.
Unit 3
Lea Park Fm.
Marie Creek Fm.
Beaver River
Jackfish Creek
Hilda Lake Member
Sand River Fm.
Ethel Lake Fm.
Bronson Lake Valley
Beverly Valley
Helina Valley
North
600
575
550
525
500
475
450

☐	UNIT 2	Silt and clay; undivided fluvial and glaciolacustrine sediment
☐	UNIT 1	Sand and gravel; contains quartzite and chert clasts derived from the Cordillera; commonly referred to as preglacial Saskatchewan sand and gravel

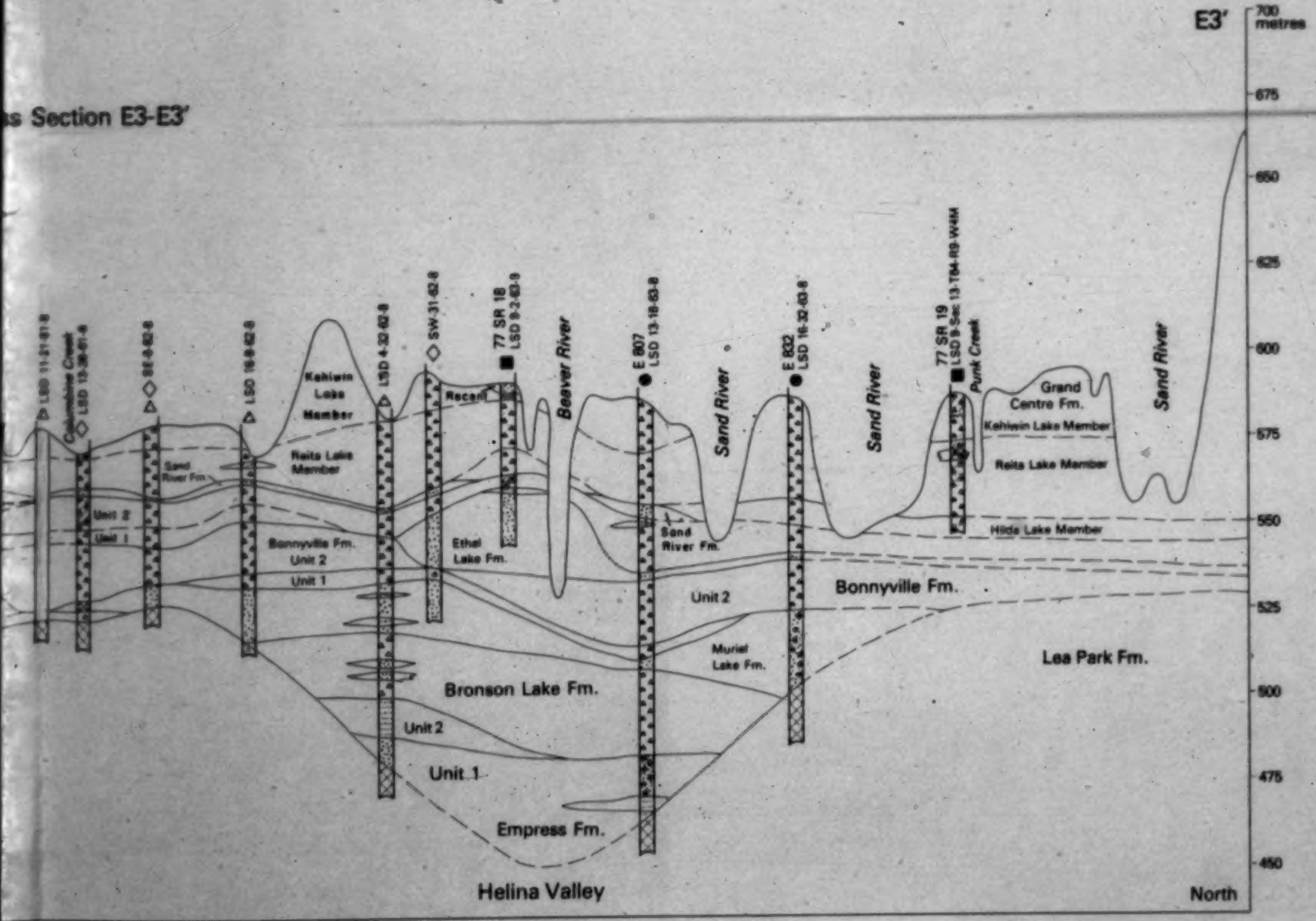
CRETACEOUS

☐	BELLY RIVER FORMATION	Grey to greenish grey, thick bedded, feldspathic sandstone; grey clayey siltstone, grey and green mudstone; concretionary ironstone beds; non-marine
☐	LEA PARK FORMATION	Dark grey shale; pale grey glauconitic, silty shale with ironstone concretions; marine

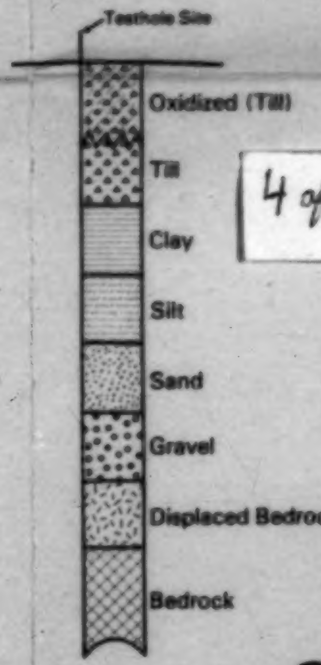
KEY MAP


NTS 73L
E4'
E3'
E2'
E1'
N2'
N2
N1'
N1
E4
E3
E2
E1

ss Section E3-E3'


E3'
700 metres
675
650
625
600
575
550
525
500
475
450
Kehiwin Lake Member
Reita Lake Member
Sand River Fm.
Beaver River
Sand River
Sand River
Sand River
Grand Centre Fm.
Kehiwin Lake Member
Reita Lake Member
Punk Creek
Hilda Lake Member
Ethel Lake Fm.
Sand River Fm.
Bonnyville Fm.
Unit 2
Unit 1
Unit 2
Unit 1
Unit 2
Bonnyville Fm.
Lea Park Fm.
Muriel Lake Fm.
Bronson Lake Fm.
Unit 2
Unit 1
Empress Fm.
Helina Valley
North
E 807 LSD 13-18-63-8
E 832 LSD 16-32-63-8
77 SR 18 LSD 9-2-63-9
77 SR 19
SW-31-62-8
LSD 4-32-62-8

TESTHOLE LITHOLOGIES


Testhole Site
Oxidized (Till)
Till
Clay
Silt
Sand
Gravel
Displaced Bedrock
Bedrock

NOTE:
Testholes may show various combinations of lithologies

Example:
Sand and Gravel ▨

4 of 4

LEGEND

Alberta Research Council Auger Testhole	■
Alberta Environment Rotary Testhole - with E-Log	●
Water Well - with E-Log	○
Water Well - without E-Log	◇
Oil Well - with E-Log	△

Unit Boundary
defined ―――
approximate — — —

Stratigraphy by L.D. Andriashek, 1984
Cartography by Alberta Research Council Graphic Services, Dan Magee

Alberta
RESEARCH COUNCIL
Natural Resources Division

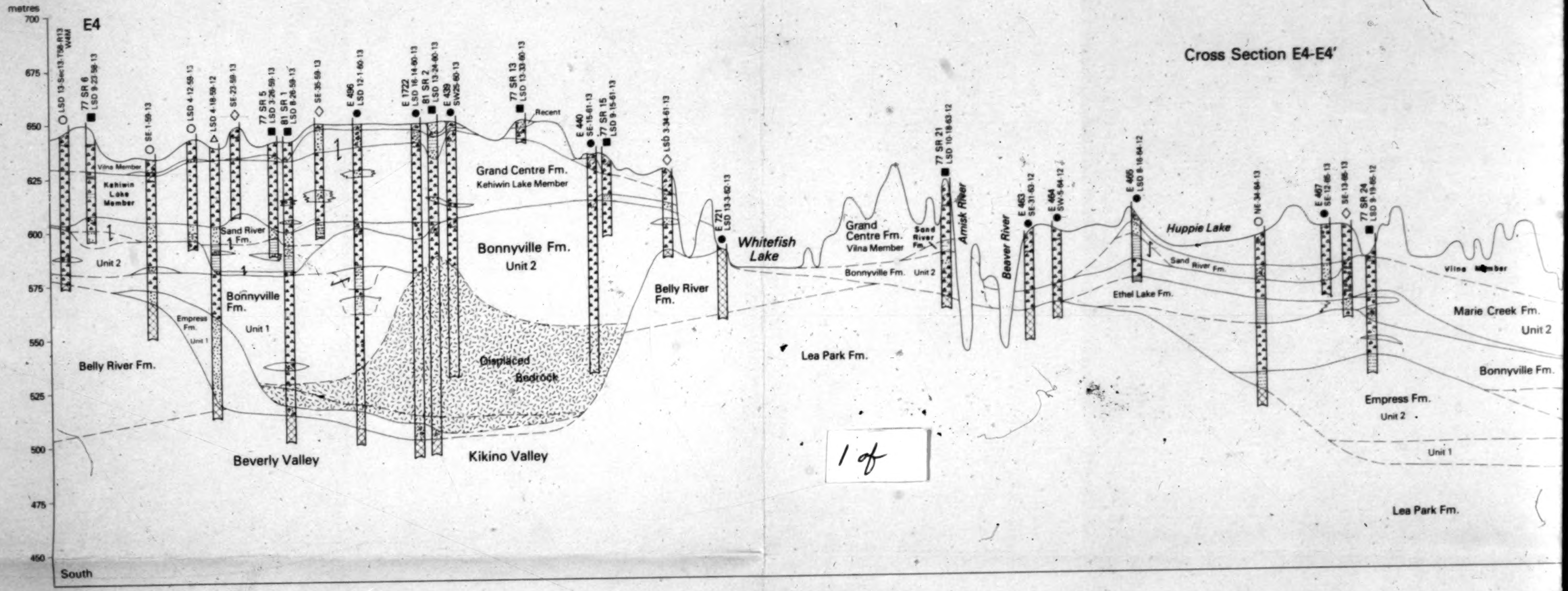
Alberta Geological Survey

QUATERNARY STRATIGRAPHY OF THE SAND RIVER MAP AREA

Figure 8: Cross Sections E1-E1', E2-E2', E3-E3'
Alberta
NTS 73L
L.D. Andriashek 1984

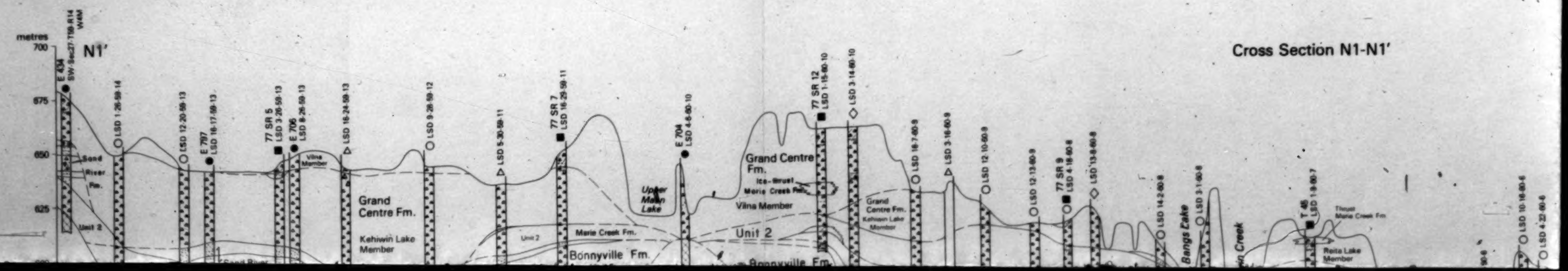
Vertical Exaggeration 130 x
Scale 1:200,000

Kilometres 5 0 5 10 15 20 25 30 Kilometres
Miles 5 0 5 10 15 20 Miles


Cross Section E4-E4′

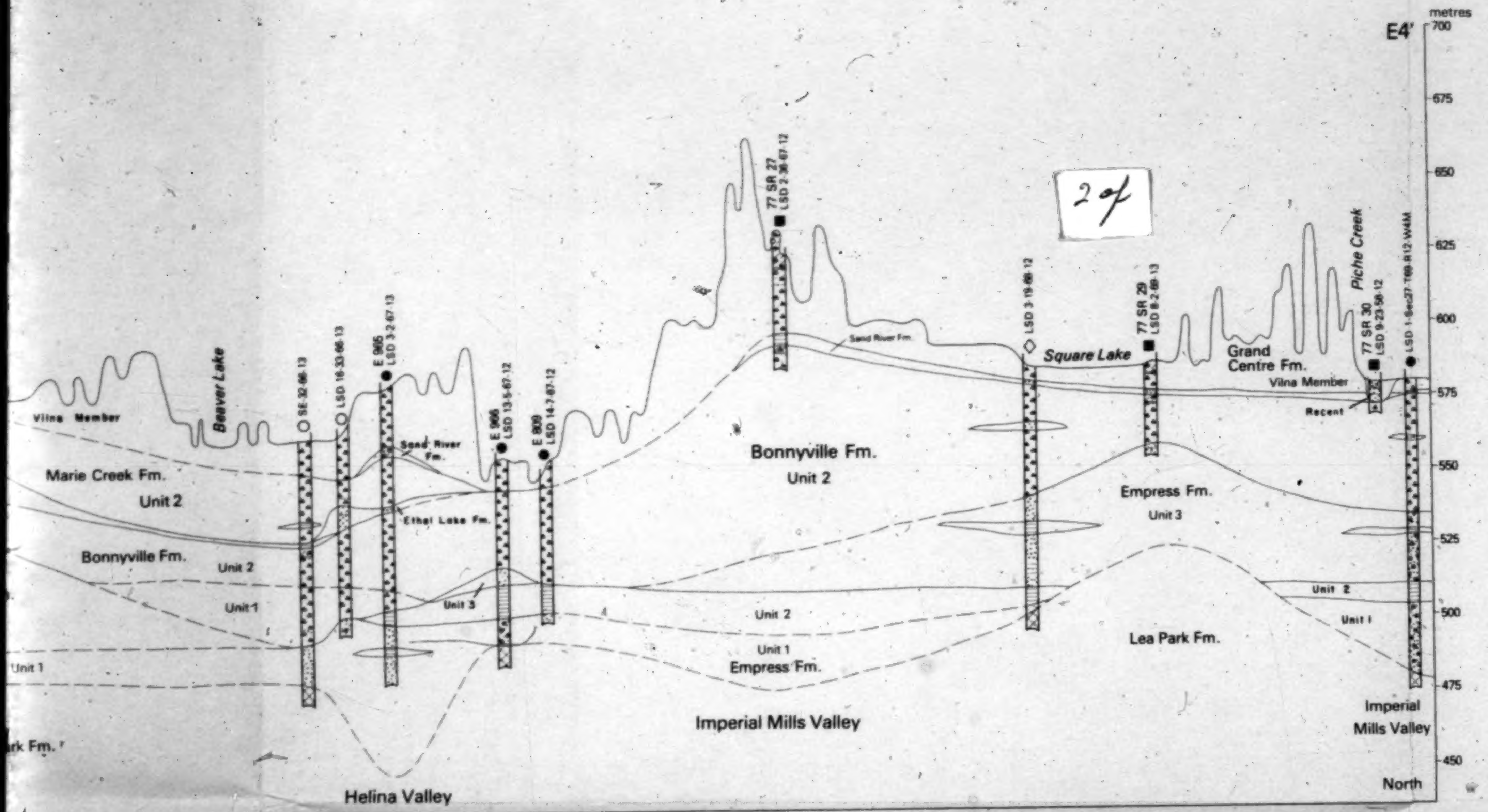
metres
700
675
650
625
600
575
550
525
500
475
450
E4
South
LSD 13-Sec13-T59-R13 W4M
77 SR 6
LSD 9-23-58-13
SE-1-59-13
LSD 4-12-59-13
LSD 4-18-59-12
SE-23-59-13
77 SR 5
LSD 3-26-59-13
81 SR 1
LSD 8-26-59-13
SE-35-59-13
E 496
LSD 12-1-60-13
E 1722
LSD 16-14-60-13
81 SR 2
LSD 13-24-60-13
E 439
SW25-60-13
77 SR 13
LSD 13-33-60-13
Recent
E 440
SE-15-61-13
77 SR 15
LSD 9-15-61-13
LSD 3-34-61-13
E 721
LSD 13-3-62-13
77 SR 21
LSD 10-18-63-12
E 463
SE-31-63-12
E 464
SW-5-64-12
E 465
LSD 8-16-64-12
NE-34-64-13
E 467
SE-12-65-13
SE-13-65-13
77 SR 24
LSD 9-19-65-12
Vilna Member
Kehiwin Lake Member
Sand River Fm.
Unit 2
Bonnyville Fm.
Empress Fm.
Unit 1
Belly River Fm.
Grand Centre Fm.
Kehiwin Lake Member
Bonnyville Fm.
Unit 2
Displaced Bedrock
Beverly Valley
Kikino Valley
Belly River Fm.
Whitefish Lake
Grand Centre Fm.
Vilna Member
Sand River Fm.
Bonnyville Fm. Unit 2
Amisk River
Beaver River
Lea Park Fm.
Huppie Lake
Sand River Fm.
Ethel Lake Fm.
Vilna Member
Marie Creek Fm.
Unit 2
Bonnyville Fm.
Empress Fm.
Unit 2
Unit 1
Lea Park Fm.

1 of

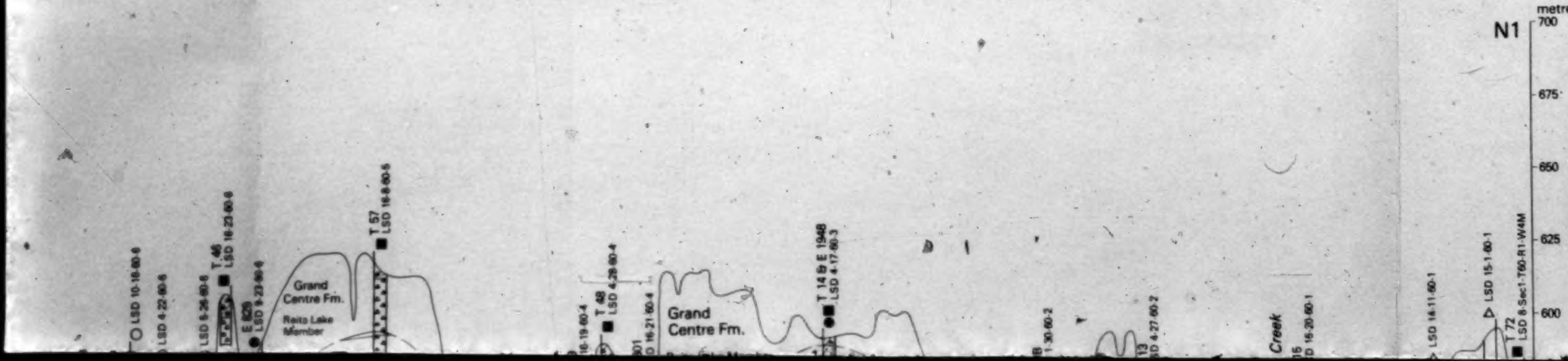

Cross Section N1-N1′

metres
700
675
650
625
N1′
E 434
SW-Sec27-T59-R14 W4M
LSD 1-26-59-14
LSD 12-20-59-13
E 787
LSD 16-17-59-13
77 SR 5
LSD 3-26-59-13
E 706
LSD 8-26-59-13
LSD 16-24-59-13
LSD 9-28-59-12
LSD 5-30-58-11
77 SR 7
LSD 16-29-59-11
E 704
LSD 4-6-60-10
77 SR 12
LSD 1-15-60-10
LSD 3-14-60-10
LSD 16-7-60-9
LSD 3-18-60-9
LSD 12-10-60-9
LSD 12-13-60-9
77 SR 9
LSD 4-18-60-8
LSD 13-8-60-8
LSD 14-2-60-8
LSD 3-1-60-8
T 45
LSD 1-9-60-7
LSD 10-16-60-6
LSD 4-22-60-6
Sand River Fm.
Unit 2
Vilna Member
Grand Centre Fm.
Kehiwin Lake Member
Unit 2
Marie Creek Fm.
Bonnyville Fm.
Upper Mann Lake
Grand Centre Fm.
Ice-thrust Marie Creek Fm.
Vilna Member
Unit 2
Bonnyville Fm.
Grand Centre Fm. Kehiwin Lake Member
Bangs Lake
Thrust Marie Creek Fm.
Reita Lake Member

2 of



E4'
metres
700
675
650
625
600
575
550
525
500
475
450
Vilna Member
Beaver Lake
SE 32-66-13
LSD 16-33-66-13
E 965
LSD 3-2-67-13
Sand River Fm.
E 966
LSD 13-5-67-12
E 809
LSD 14-7-67-12
Marie Creek Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
Unit 1
Unit 3
Unit 1
ark Fm.
Helina Valley
77 SR 27
LSD 2-36-67-12
Sand River Fm.
Bonnyville Fm.
Unit 2
Unit 2
Unit 1
Empress Fm.
Imperial Mills Valley
LSD 3-19-68-12
Square Lake
77 SR 29
LSD 8-2-69-13
Grand Centre Fm.
Vilna Member
Empress Fm.
Unit 3
Lea Park Fm.
Piche Creek
77 SR 30
LSD 9-23-58-12
LSD 1-Sec27-T69-R12-W4M
Recent
Unit 2
Unit 1
Imperial Mills Valley
North



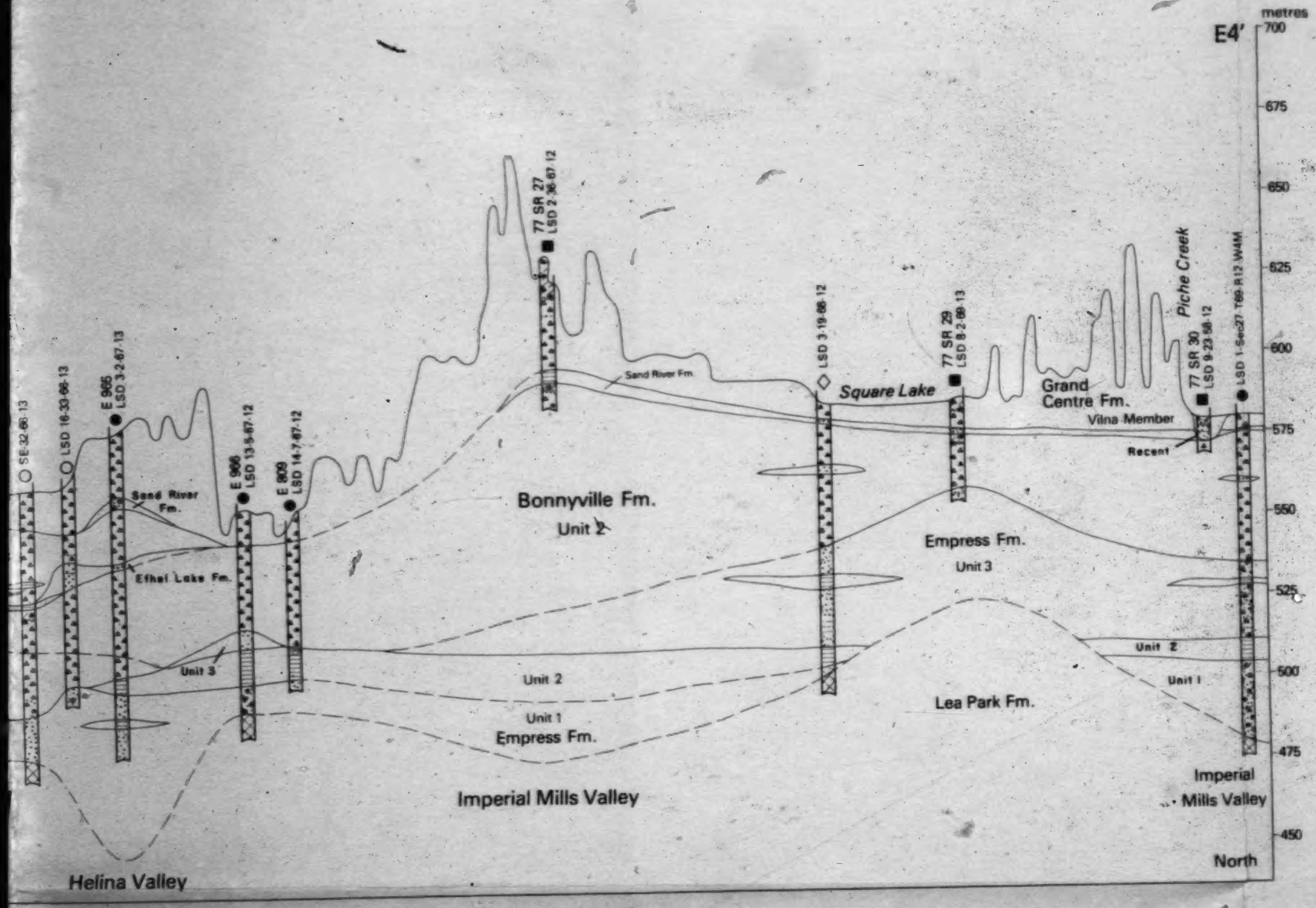
N1
metres
700
675
650
625
600
LSD 10-18-60-6
LSD 4-22-60-6
LSD 5-26-60-6
E 829
LSD 9-23-60-6
T 46
LSD 16-23-60-6
Grand Centre Fm.
Reita Lake Member
T 57
LSD 16-8-60-5
T 48
LSD 4-28-60-4
LSD 16-21-60-4
Grand Centre Fm.
T 14 & E 1948
LSD 4-17-60-3
Creek
LSD 16-11-60-1
LSD 15-1-60-1
T 72
LSD 8-Sec1-T60-R1-W4M

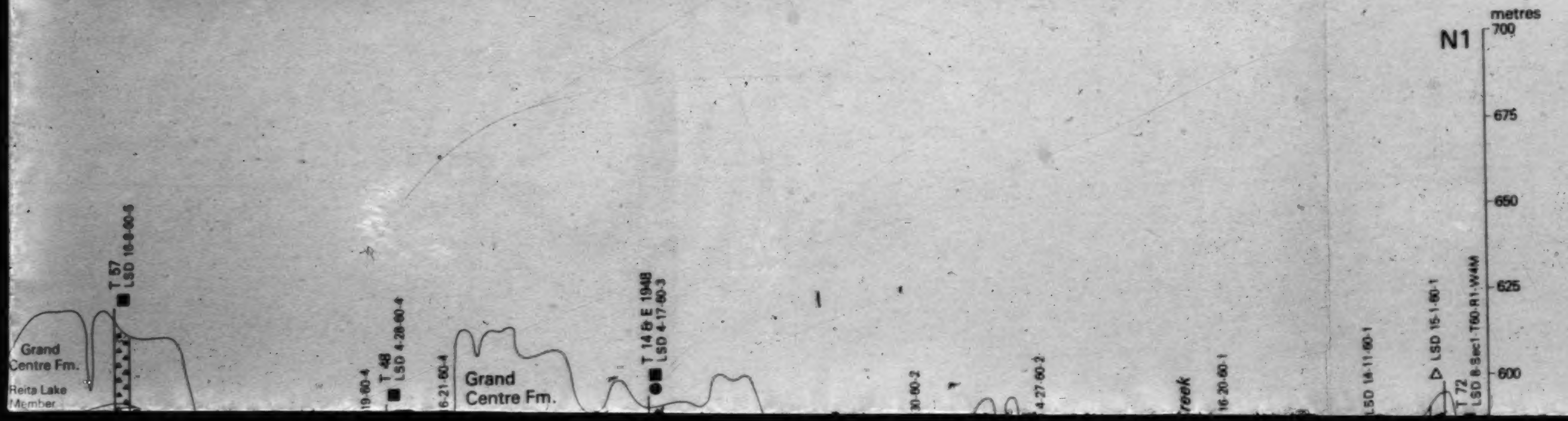
Quaternary Stratigraphy of the Sand River M

QUATERNARY

HOLOCENE
(RECENT)

☐	POST GLACIAL STRATIFIED DEPOSITS	Clay, silt, sand, gravel; undifferentiated eolian, deposits
	PLEISTOCENE	
	GRAND CENTRE FORMATION	
☐	VILNA MEMBER	Clayey diamicton; contains abundant blocks of older sediment; very coarse sand fraction is rich metamorphic rock fragments; glacial sediment
☐	KEHIWIN LAKE MEMBER	Sandy diamicton; very coarse sand fraction is phic and quartz rock fragments; glacial sedimer
☐	REITA LAKE MEMBER	Clayey-sand diamicton; very coarse sand fractio metamorphic rock fragments; glacial sediment
☐	HILDA LAKE MEMBER	Clayey diamicton; contains abundant blocks of older sediment; very coarse sand fraction rich phic rock fragments; glacial sediment (till)
☐	SAND RIVER FORMATION	Sand and gravelly sand; minor silt and clay; gl
	MARIE CREEK FORMATION	
☐	UNIT 2	Sandy diamicton; very coarse sand fraction ric fragments; glacial sediment (till)
☐	UNIT 1	Clayey diamicton; contains discrete lenses of coarse sand fraction rich in carbonate rock fra (till)
☐	ETHEL LAKE FORMATION	Silt and clay; minor sand and gravel; predomi sediment
	BONNYVILLE FORMATION	
☐	UNIT 2	Diamicton; sandy in east two thirds of map ar coarse sand fraction rich in quartz fragments;
☐	UNIT 1	Clayey diamicton; recognized by very low resi sediment (till) that is overlain by sand and gra
☐	MURIEL LAKE FORMATION	Sand and gravel; minor silt and clay; glacioflu
☐	BRONSON LAKE FORMATION	Clayey diamicton and clay undivided; recogni resistivity response; very coarse sand fraction bedrock fragments; mixed glacial sediment (ti sediment
	EMPRESS FORMATION	
☐	UNIT 3	Sand and gravel; contains igneous and meta the Canadian Shield; glaciofluvial sediment
☐	UNIT 2	Silt and clay; undivided fluvial and glaciolacu
☐	UNIT 1	Sand and gravel; contains quartzite and che Cordillera; commonly referred to as preglacia gravel

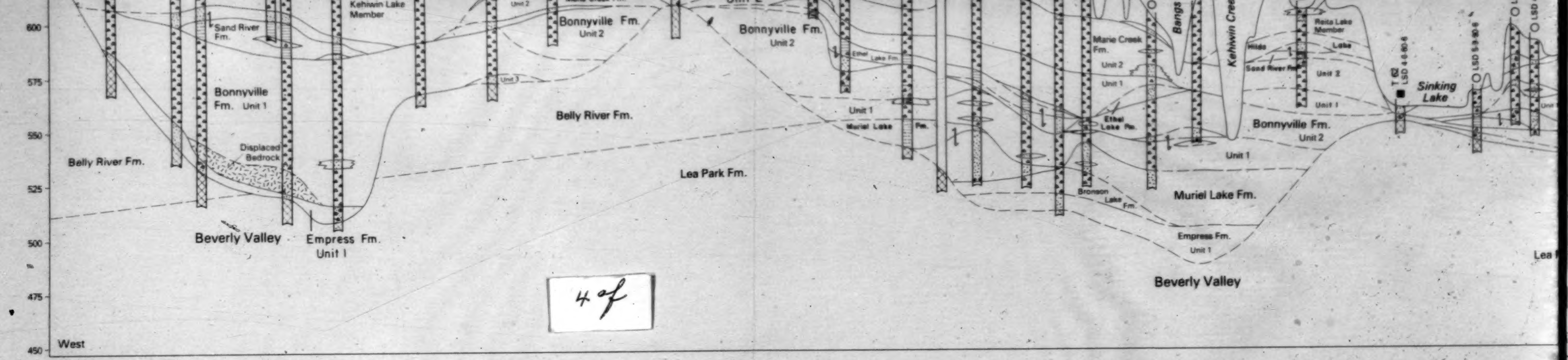

E4'
metres
700
675
650
625
600
575
550
525
500
475
450
SE-32-66-13
LSD 16-33-66-13
E 965
LSD 3-2-67-13
E 966
LSD 13-5-67-12
E 909
LSD 14-7-67-12
77 SR 27
LSD 2-36-67-12
LSD 3-19-68-12
77 SR 29
LSD 8-2-69-13
77 SR 30
LSD 9-23-68-12
LSD 1-Sec27-T69-R12-W4M
Piche Creek
Square Lake
Grand
Centre Fm.
Vilna Member
Recent
Sand River Fm.
Sand River
Fm.
Ethel Lake Fm.
Bonnyville Fm.
Unit 2
Empress Fm.
Unit 3
Unit 3
Unit 2
Unit 1
Empress Fm.
Lea Park Fm.
Unit 2
Unit 1
Imperial Mills Valley
Imperial
Mills Valley
Helina Valley
North


N1
metres
700
675
650
625
600
Grand
Centre Fm.
Reita Lake
Member
T 57
LSD 16-8-60-5
T 48
LSD 4-28-60-4
T 14 & E 1948
LSD 4-17-60-3
Grand
Centre Fm.
LSD 14-11-60-1
LSD 15-1-60-1
T 72
LSD 8-Sec1-T60-R1-W4M

3of

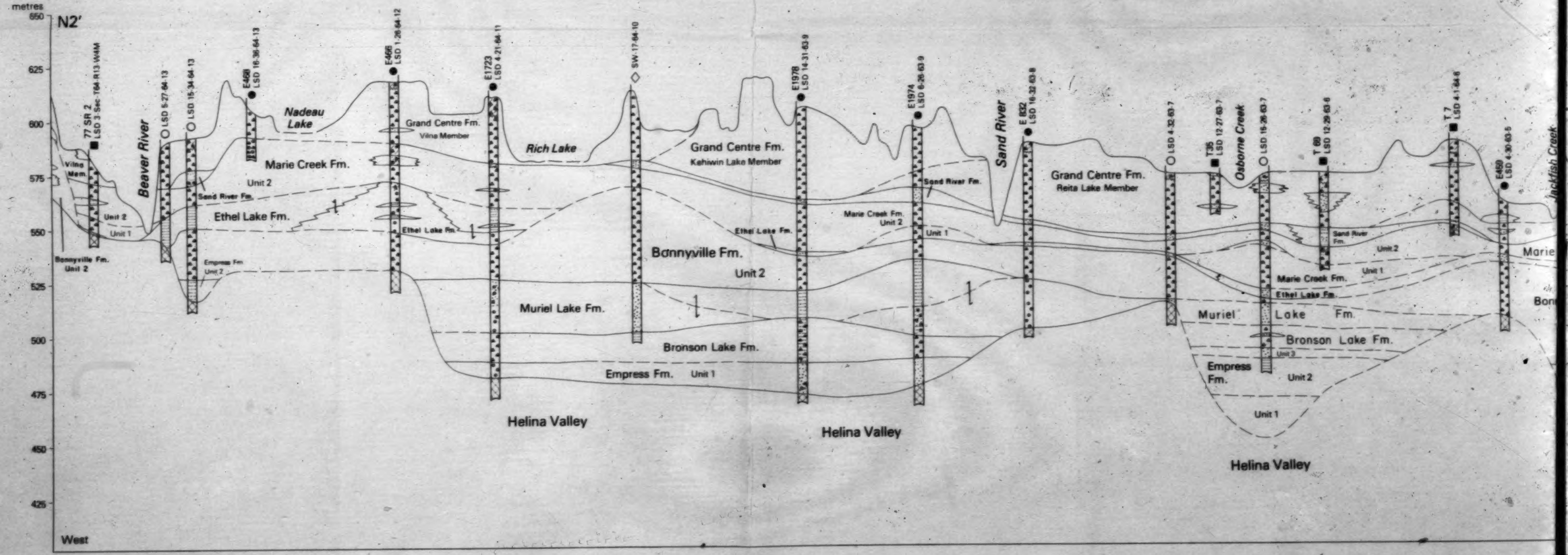
Quaternary Stratigraphy of the Sand River Map Area

	QUATERNARY	
	HOLOCENE (RECENT)	
☐	**POST GLACIAL STRATIFIED DEPOSITS**	Clay, silt, sand, gravel; undifferentiated eolian, fluvial, and lacustrine deposits
	PLEISTOCENE	
	GRAND CENTRE FORMATION*	
☐	**VILNA MEMBER**	Clayey diamicton; contains abundant blocks of glacially transported older sediment; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
☐	**KEHIWIN LAKE MEMBER**	Sandy diamicton; very coarse sand fraction is rich in igneous, metamorphic and quartz rock fragments; glacial sediment (till)
☐	**REITA LAKE MEMBER**	Clayey-sand diamicton; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
☐	**HILDA LAKE MEMBER**	Clayey diamicton; contains abundant blocks of glacially transported older sediment; very coarse sand fraction rich in igneous and metamorphic rock fragments; glacial sediment (till)
☐	**SAND RIVER FORMATION**	Sand and gravelly sand; minor silt and clay; glaciofluvial sediment
	MARIE CREEK FORMATION	
☐	**UNIT 2**	Sandy diamicton; very coarse sand fraction rich in carbonate rock fragments; glacial sediment (till)
☐	**UNIT 1**	Clayey diamicton; contains discrete lenses of bedded silt and clay; very coarse sand fraction rich in carbonate rock fragments; glacial sediment (till)
☐	**ETHEL LAKE FORMATION**	Silt and clay; minor sand and gravel; predominantly glaciolacustrine sediment
	BONNYVILLE FORMATION	
☐	**UNIT 2**	Diamicton; sandy in east two thirds of map area, clayey in west; very coarse sand fraction rich in quartz fragments; glacial sediment (till)
☐	**UNIT 1**	Clayey-diamicton; recognized by very low resistivity response; glacial sediment (till) that is overlain by sand and gravel in some places
☐	**MURIEL LAKE FORMATION**	Sand and gravel; minor silt and clay; glaciofluvial sediment
☐	**BRONSON LAKE FORMATION**	Clayey diamicton and clay undivided; recognized primarily by very low resistivity response; very coarse sand fraction rich in quartz and shale bedrock fragments; mixed glacial sediment (till) and glaciolacustrine sediment
	EMPRESS FORMATION	
☐	**UNIT 3**	Sand and gravel; contains igneous and metamorphic clasts derived from the Canadian Shield; glaciofluvial sediment
☐	**UNIT 2**	Silt and clay; undivided fluvial and glaciolacustrine sediment
☐	**UNIT 1**	Sand and gravel; contains quartzite and chert clasts derived from the Cordillera; commonly referred to as preglacial Saskatchewan sand and gravel


600
575
550
525
500
475
450
West
Kehiwin Lake Member
Sand River Fm.
Bonnyville Fm. Unit 1
Bonnyville Fm. Unit 2
Belly River Fm.
Displaced Bedrock
Beverly Valley
Empress Fm. Unit 1
Lea Park Fm.
Marie Creek Fm.
Unit 2
Unit 1
Ethel Lake Fm.
Muriel Lake Fm.
Bronson Lake Fm.
Bangs
Kehiwin Creek
Reita Lake Member
Sand River Fm.
T 62 LSD 4-8-60-6
Sinking Lake
LSD 5-9-60-6
Empress Fm. Unit 1
Beverly Valley
Lea

4 of

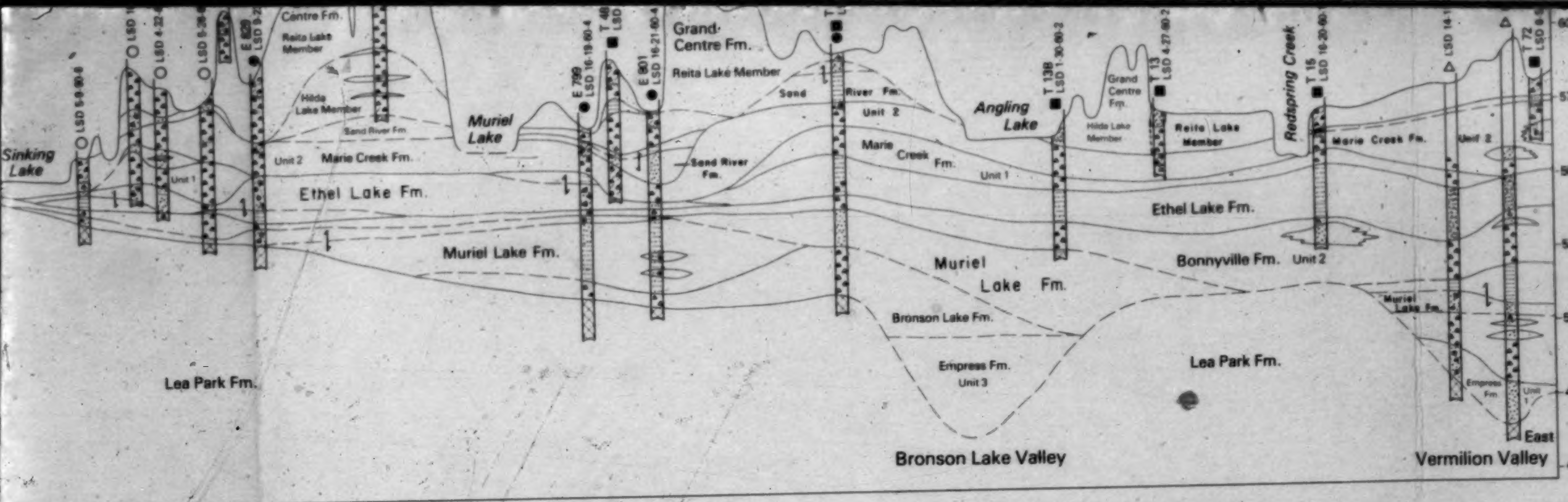
Cross Section N2-N2'

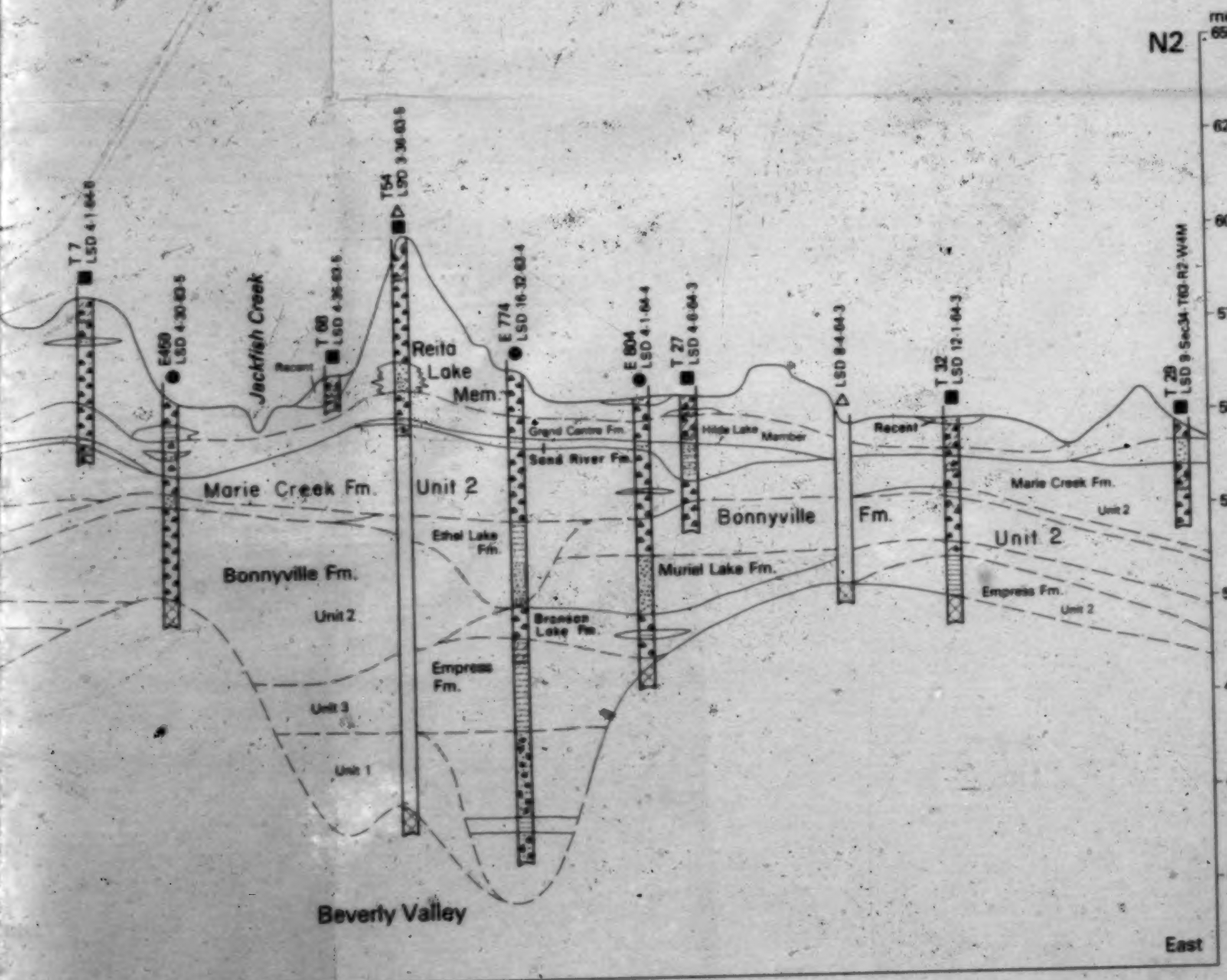

metres
650
625
600
575
550
525
500
475
450
425
N2'
West
77 SR 2 LSD 3 Sec. T64 R13 W4M
Beaver River
LSD 5-27-64-13
LSD 15-34-64-13
E458 LSD 16-36-64-13
Nadeau Lake
E466 LSD 1-26-64-12
E1723 LSD 4-21-64-11
SW-17-64-10
Rich Lake
E1978 LSD 14-31-63-9
E1974 LSD 6-26-63-9
Sand River
E 832 LSD 16-32-63-8
LSD 4-32-63-7
T35 LSD 12-27-63-7
Osborne Creek
LSD 16-26-63-7
T 69 LSD 12-29-63-6
T 7 LSD 4-1-64-6
E459 LSD 4-30-63-5
Jackfish Creek
Vilna Mem.
Unit 2
Unit 1
Bonnyville Fm. Unit 2
Grand Centre Fm.
Vilna Member
Marie Creek Fm.
Unit 2
Sand River Fm.
Ethel Lake Fm.
Empress Fm. Unit 2
Ethel Lake Fm.
Grand Centre Fm.
Kehiwin Lake Member
Bonnyville Fm.
Unit 2
Muriel Lake Fm.
Bronson Lake Fm.
Empress Fm. Unit 1
Ethel Lake Fm.
Marie Creek Fm. Unit 2
Unit 1
Sand River Fm.
Grand Centre Fm.
Reita Lake Member
Sand River Fm.
Unit 2
Unit 1
Marie Creek Fm.
Ethel Lake Fm.
Muriel Lake Fm.
Bronson Lake Fm.
Unit 3
Empress Fm.
Unit 2
Unit 1
Marie
Bon
Helina Valley
Helina Valley
Helina Valley

UNIT 1 Cordillera; commonly referred to as preglacia
gravel

CRETACEOUS

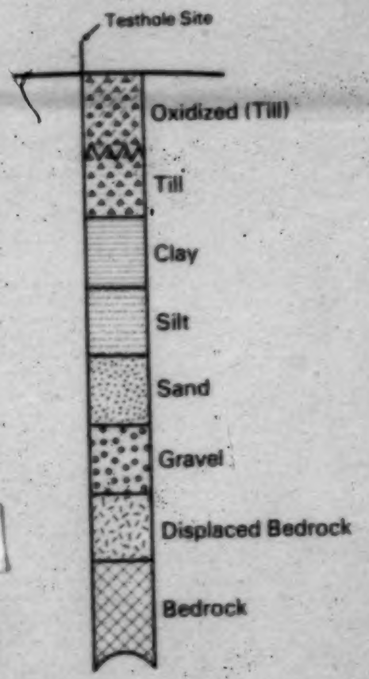
☐	BELLY RIVER FORMATION	Grey to greenish grey, thick bedded, feldspa clayey siltstone, grey and green mudstone; c beds; non-marine.
☐	LEA PARK FORMATION	Dark grey shale; pale grey glacuconitic, silty cretions; marine


Sinking Lake
Muriel Lake
Angling Lake
Redspring Creek
Grand Centre Fm.
Reita Lake Member
Hilda Lake Member
Sand River Fm.
Unit 2
Unit 1
Marie Creek Fm.
Ethel Lake Fm.
Muriel Lake Fm.
Bonnyville Fm.
Bronson Lake Fm.
Empress Fm.
Unit 3
Lea Park Fm.
Bronson Lake Valley
Vermilion Valley
East
600
575
550
525
500
475
450


N2
metres
650
625
600
575
550
525
500
475
450
425
T 7
E459
Jackfish Creek
T 68
T54
Reita Lake Mem.
E 774
E 804
T 27
T 32
T 29
Recent
Grand Centre Fm.
Sand River Fm.
Hilda Lake Member
Marie Creek Fm.
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Muriel Lake Fm.
Bronson Lake Fm.
Empress Fm.
Unit 3
Unit 1
Beverly Valley
East

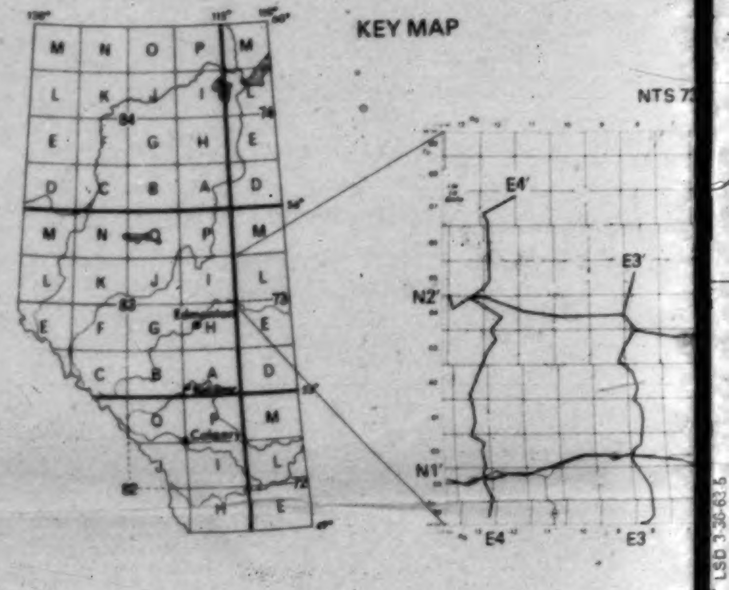
5 of

TESTHOLE LITHOLOGIES


Testhole Site
Oxidized (Till)
Till
Clay
Silt
Sand
Gravel
Displaced Bedrock
Bedrock

NOTE:
Testholes may show
various combinations
of lithologies

Example:
Sand and Gravel ▨


KEY MAP
NTS 7
E4'
E3'
N2'
N1'
E4
E3

LEGEND

Alberta Research Council Auger Testhole	■
Alberta Environment Rotary Testhole - with E-Log	●
Water Well - with E-Log	○
Water Well - without E-Log	◇
Oil Well - with E-Log	△
Unit Boundary	
defined	———
approximate	— — —

Stratigraphy by L.D. Andriashek, 1984
Cartography by Alberta Research Council Graphic Services, Dan Magee

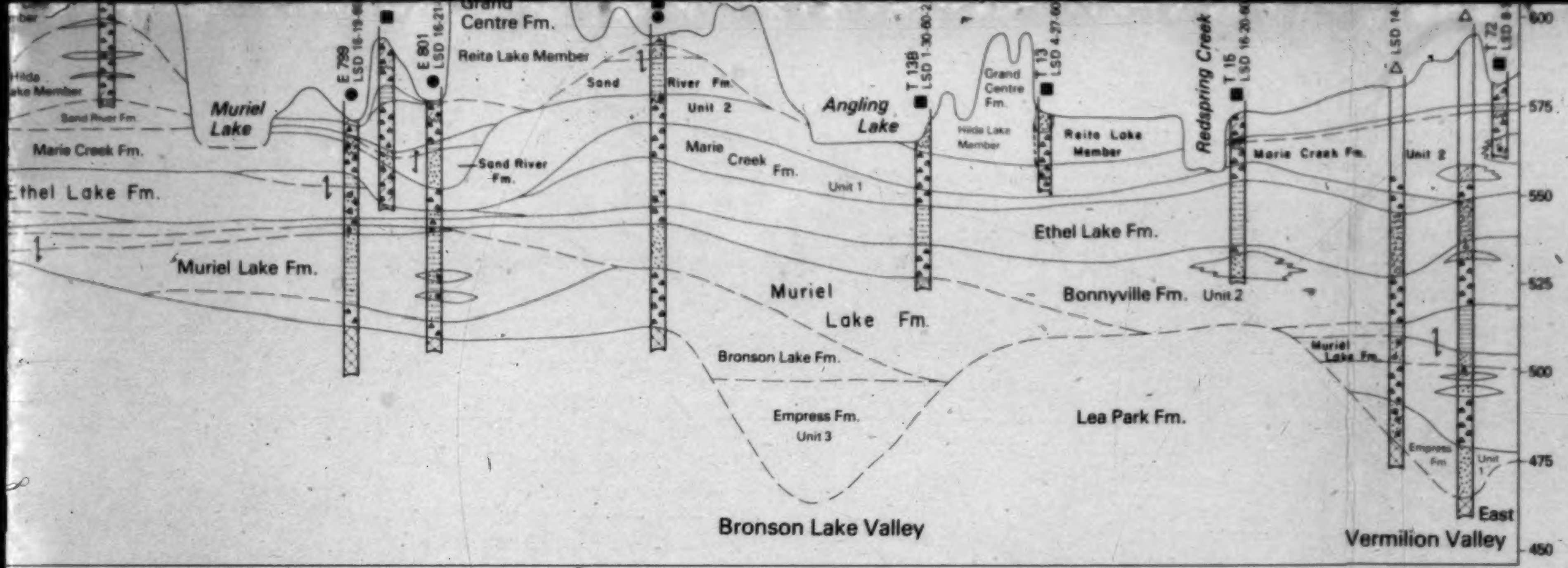
RESEARC
Natural Resou

Alberta Geolo

QUATERNARY STRATIGRAPHY OF TH SAND RIVER MAP AREA

Figure 9: Cross Sections E4-E4′, N1-N2′, N2-N2′
Alberta
NTS 73L
L.D. Andriashek 1984
Vertical Exaggeration 130 x
Scale 1:200,000

Kilometres 5 0 5 10 15 20 25
Miles 5 0 5 10 15

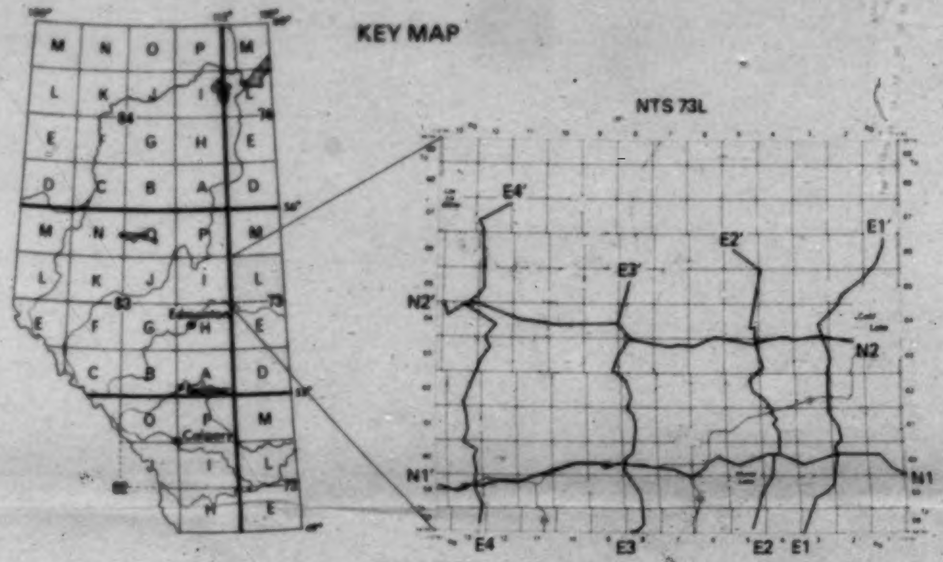

Grand Centre Fm.
Reita Lake Member
Hilda Lake Member
Sand River Fm.
Muriel Lake
Marie Creek Fm.
Ethel Lake Fm.
Muriel Lake Fm.
E 799 LSD 16-19-
E 801 LSD 16-21-
Sand River Fm.
Sand River Fm.
Unit 2
Marie Creek Fm.
Unit 1
Angling Lake
T 138 LSD 1-30-
Grand Centre Fm.
Hilda Lake Member
T 13 LSD 4-27-
Reita Lake Member
Redspring Creek
T 15 LSD 16-20-
Marie Creek Fm.
Ethel Lake Fm.
Muriel Lake Fm.
Bonnyville Fm. Unit 2
Bronson Lake Fm.
Empress Fm. Unit 3
Lea Park Fm.
LSD 14
T 72 LSD
Unit 2
Muriel Lake Fm.
Empress Fm
Unit 1
East
Bronson Lake Valley
Vermilion Valley
600
575
550
525
500
475
450

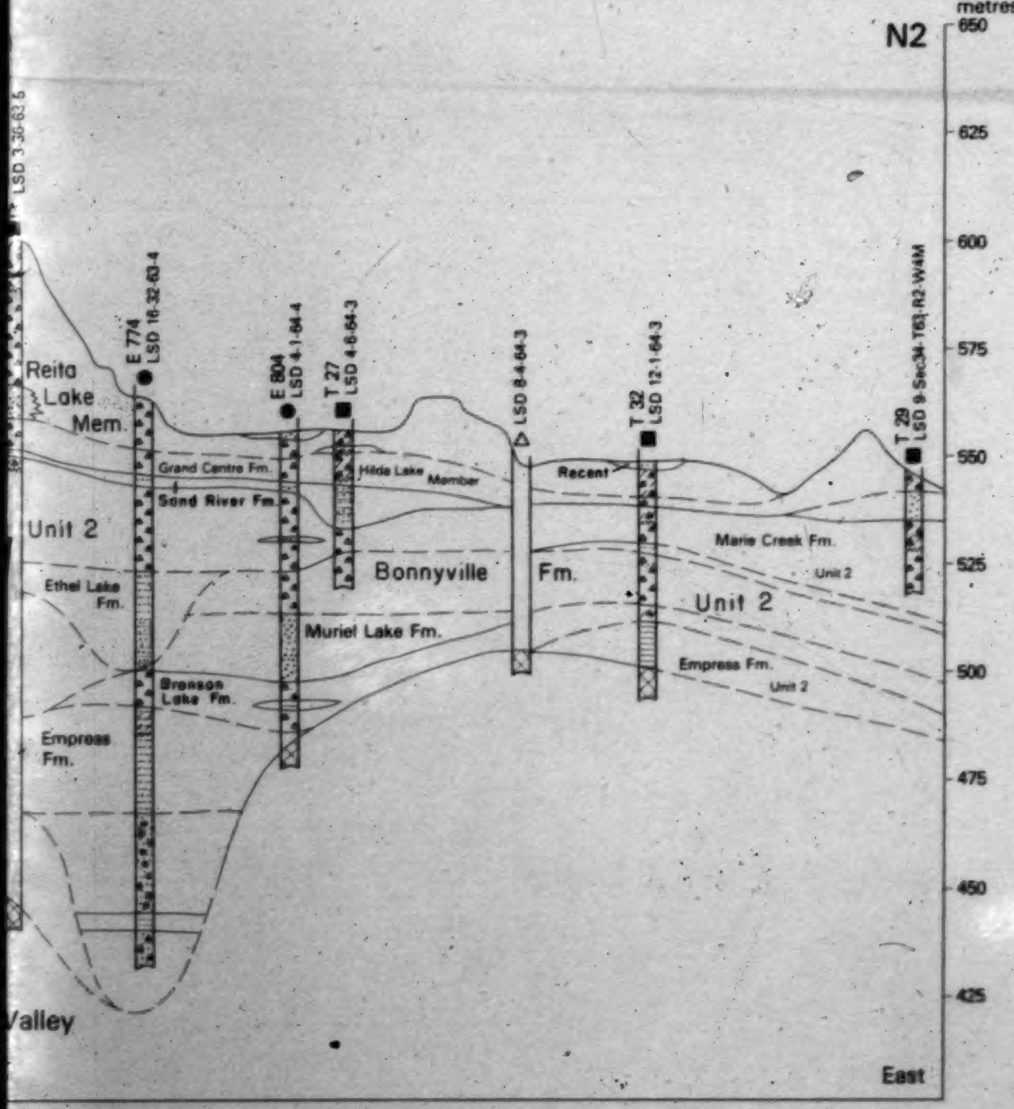
UNIT 1 — Sand and gravel; contains quartzite and chert clasts derived from the Cordillera; commonly referred to as preglacial Saskatchewan sand and gravel

CRETACEOUS

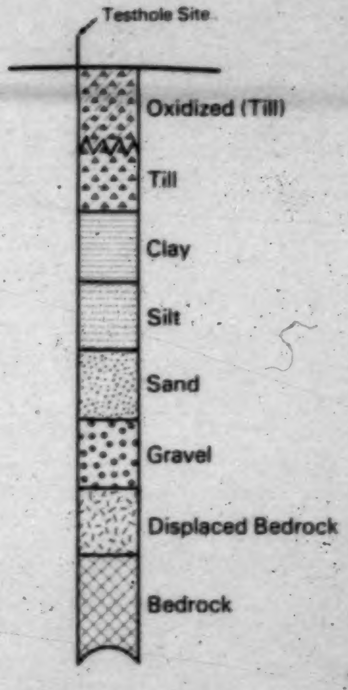
☐	BELLY RIVER FORMATION	Grey to greenish grey, thick bedded, feldspathic sandstone; grey clayey siltstone, grey and green mudstone; concretionary ironstone beds; non-marine.
☐	LEA PARK FORMATION	Dark grey shale; pale grey glacuconitic, silty shale with ironstone concretions; marine

KEY MAP


M
N
O
P
M
L
K
J
I
H
G
F
E
D
C
B
A
84
74
83
73
82
72
Edmonton
Calgary
NTS 73L
E4'
E3'
E2'
E1'
N2'
N2
N1'
N1
E4
E3
E2
E1


N2
metres
650
625
600
575
550
525
500
475
450
425
Reita Lake Mem.
E 774 LSD 16-32-63-4
E 804 LSD 4-1-64-4
T 27 LSD 4-6-64-3
LSD 8-4-64-3
T 32 LSD 12-1-64-3
T 29 LSD 9-Sec34-T63-R2-W4M
Grand Centre Fm.
Sand River Fm.
Hilda Lake Member
Recent
Unit 2
Ethel Lake Fm.
Bonnyville Fm.
Marie Creek Fm.
Unit 2
Unit 2
Muriel Lake Fm.
Empress Fm.
Unit 2
Bronson Lake Fm.
Empress Fm.
Valley
East

TESTHOLE LITHOLOGIES


Testhole Site
Oxidized (Till)
Till
Clay
Silt
Sand
Gravel
Displaced Bedrock
Bedrock

NOTE:
Testholes may show various combinations of lithologies

Example:
Sand and Gravel

LEGEND

Alberta Research Council Auger Testhole	■
Alberta Environment Rotary Testhole - with E-Log	●
Water Well - with E-Log	○
Water Well - without E-Log	◇
Oil Well - with E-Log	△

Unit Boundary
defined ―――
approximate – – –

Stratigraphy by L.D. Andriashek, 1984
Cartography by Alberta Research Council Graphic Services, Dan Magee

Alberta
RESEARCH COUNCIL
Natural Resources Division

Alberta Geological Survey

QUATERNARY STRATIGRAPHY OF THE SAND RIVER MAP AREA

Figure 9: Cross Sections E4-E4', N1-N2', N2-N2'

Alberta
NTS 73L
L.D. Andriashek 1984
Vertical Exaggeration 130 x
Scale 1:200,000

6 of 6

Kilometres 5 0 5 10 15 20 25 30 Kilometres
Miles 5 0 5 10 15 20 Miles